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MOBILE GEOSPATIAL INFORMATION SYSTEMS FOR LAND FORCE OPERATIONS: ANALYSIS OF OPERATIONAL NEEDS AND RESEARCH OPPORTUNITIES

by:

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14. ABSTRACT

Geospatial Data Visualization is an Applied Research Project (ARP) that investigates human factors issues associated with geospatial data visualization in a mobile Geographic Information System (GIS) environment. The work covered by this report represents a scoping phase of the project. It analyzes the CF operational needs and research for cost-effective opportunities for utilizing these technologies in land forces operations. The first milestone of this scoping study investigated the front-end usability of current mobile GIS systems. Human factors issues associated with geovisualization were analysed with reference to findings that pertained to mapping requirements identified in the SIREQ TD. An extensive technology review was conducted with emphasis on the functionality associated with effective visualization and processing of large volumes of geospatial data on mobile devices. This review also included identifying relevant military tasks, in which mobile GIS systems could be effectively used. A complete list of technical and operational requirements was created and mapped onto existing commercial and military mobile GIS systems in the second milestone. A workshop was conducted as the third milestone where SMEs and operational level military officers discussed the operational tasks identified in the first two milestones. The workshop participants elaborated on some of the currents needs and identified scenario-based operational requirements and gaps that hinder effective use of mobile GIS systems. Findings of the three milestones led to the development of a human factors research plan in the last milestone. The developed research plan introduced research challenges that might be further explored through future analyses and laboratory and field studies of the issues associated with the use of mobile GIS systems for land forces.

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Abstract

Geospatial Data Visualization is an Applied Research Project (ARP) that investigates human factors issues associated with geospatial data visualization in a mobile Geographic Information System (GIS) environment. The work covered by this report represents a scoping phase of the project. It analyzes the CF operational needs and research for cost-effective opportunities for utilizing these technologies in land forces operations. The first milestone of this scoping study investigated the front-end usability of current mobile GIS systems. Human factors issues associated with geovisualization were analysed with reference to findings that pertained to mapping requirements identified in the SIREQ TD. An extensive technology review was conducted with emphasis on the functionality associated with effective visualization and processing of large volumes of geospatial data on mobile devices. This review also included identifying relevant military tasks, in which mobile GIS systems could be effectively used. A complete list of technical and operational requirements was created and mapped onto existing commercial and military mobile GIS systems in the second milestone. A workshop was conducted as the third milestone, where SMEs and operational level military officers discussed the operational tasks identified in the first two milestones. The workshop participants elaborated on some of the currents needs and identified scenario-based operational requirements and gaps that hinder effective use of mobile GIS systems. Findings of the three milestones led to the development of a human factors research plan in the last milestone. The developed research plan introduced research challenges that might be further explored through future analyses and laboratory and field studies of the issues associated with the use of mobile GIS systems for land forces.

Résumé

Le projet de visualisation de données géospatiales s'inscrit dans le cadre du Programme de recherches appliquées (PRA), et il porte sur les questions d'ergonomie associées à la visualisation des données géospatiales dans un environnement de système d'information géographique (SIG) mobile. Les travaux couverts par le présent rapport représentent la phase de délimitation du projet. Il s'agit d'analyser les besoins opérationnels des FC et de trouver des moyens rentables d'utiliser ces technologies dans les opérations des forces terrestres. La première étape de cette étude de délimitation a porté sur la convivialité des SIG mobiles actuels. Nous avons analysé les questions d'ergonomie associées à géovisualisation en nous basant sur les conclusions touchant les besoins cartographiques du projet SIREQ TD. Nous avons examiné à fond la technologie, notamment les fonctionnalités associées à une visualisation efficace et le traitement de volumes importants de données géospatiales sur les appareils mobiles. Cet examen a également porté sur la détermination des tâches militaires pour lesquelles les SIG mobiles pourraient être utilisés efficacement. La deuxième étape a consisté à dresser une liste complète des exigences techniques et opérationnelles, et à la comparer aux caractéristiques des SIG mobiles actuels, commerciaux et militaires dans la deuxième étape. La troisième étape a consisté en un atelier où les PME et les officiers militaires de niveau opérationnel ont examiné les tâches opérationnelles définies dans les deux premières étapes. Les participants à l'atelier ont défini plus en détail certains des besoins courants et ont établi des scénarios basés sur les exigences opérationnelles et les lacunes qui empêchent une utilisation efficace des SIG mobiles. Ces trois étapes ont abouti à l'élaboration d'un plan de recherche sur les questions d'ergonomie, pour la dernière étape. Ce plan présente divers axes de recherche sur l'utilisation des SIG mobiles pour les forces terrestres qui pourraient faire l'objet d'analyses et d'études en laboratoire et sur le terrain.

Executive Summary

Mobile Geospatial Information Systems for Land Force Operations: Analysis of Operational Needs and Research Opportunities

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DRDC Toronto No. CR2010-014; Defence R&D Canada – Toronto; March 2010.

Background: The design of location-based technology systems is expected to play an important role in future military mission success. Accordingly, Defence Research and Development Canada (DRDC) has initiated an Applied Research Project (ARP) on the evaluation of human factors issues associated with geospatial data visualization in a mobile Geographic Information System (GIS) environment. This report summarizes work conducted during the scoping phase of the ARP.

Results: The first phase of this project involved extensive review of recent literature on the use of mobile GIS systems. The focus in this phase was on identifying usability measures, based on military relevant tasks, where mobile GIS systems could be used. A thorough search was conducted and a total of 20 articles were selected and reviewed. After analyzing the relevant literature, a list of 32 military operational tasks that could potentially benefit from access to mobile geospatial data was compiled. These tasks were organized by high-level military functions (e.g., attack, defend, patrol). In addition, a list of 14 physical and technical requirements for the use of handheld devices in infantry operations was generated.

The second phase involved investigation of geospatial data visualization devices. A comprehensive functional assessment of mobile GIS device capabilities was conducted. This assessment reviewed both commercial off-the-shelf (COTS) products (including smart cell phones) and Military Off-the-Shelf (MOTS) hand-held mobile GIS devices. A list of major mobile GIS devices was complied and then specifications and capabilities were analysed using manuals and product specifications solicited from manufacturers. Based on defined functionality and specifications, a set of 23 commercial devices and 10 MOTS devices were short-listed for further functional analysis. Product literature was gleaned for each device. A matrix-based analysis was conducted against operational tasks identified in phase 1 to see if and how the device met the operational tasks and physical and technical considerations. A spreadsheet was used for the metrics-based analysis with products mapped against the desired tasks and considerations.

The third phase of this project involved a workshop that was organized in coordination with the Directorate of Land Resources (DLR) and the Integrated Soldier System Project (ISSP). The workshop emphasis was on assessing user requirements, identifying operational gaps and exploring potential future solutions. Senior and middle operational level land forces officers from the DLR, ISSP and other organizations were invited to participate. Specifically, the focus of this workshop was twofold: (i) to validate the list of tasks identified and any potential gaps, and (ii) to discuss and prioritize operationally relevant uses for mobile GIS systems, as well as outline future research areas.

Finally, an initial research plan for future laboratory and field studies of human factors issues associated with the use of mobile GIS systems for land forces was created from the information collected at the workshop.

Significance: This report summarizes the results of an investigation into the capabilities of current mobile GIS systems and analyzes human factors issues associated with the effective visualization and processing of large volumes of geospatial data on handheld devices. The work reported here provides the breadth and depth required for defining the scope of the Geospatial Data Visualization ARP on the evaluation of human factors issues associated with geospatial data visualization in a mobile GIS environment.

Future Plans: Future work under this ARP will investigate current mobile GIS systems capabilities and human factors issues associated with the effective visualization and processing of large volumes of geospatial data on handheld devices. The following areas were identified as priority areas for future research:

- Symbology
- Overlays
- Clutter
- Map Based Information Sharing
- Alarms and Alerts
- Information Requirements and Filtering
- Uncertainty Representations
- Head up vs. Head down issues
- Physical Design
- Opportunities to leverage information from existing systems used in other domains

Sommaire

Systèmes d'information géographique (SIG) mobiles pour les opérations des forces terrestres : Analyse des besoins opérationnels et axes de recherche possibles

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RDDC Toronto No. CR2010-014; R&D pour la defense Canada – Toronto; mars 2010.

Contexte : Les systèmes basés sur la technologie géospatiale sont appelés à jouer un rôle important dans la réussite des futures missions militaires. En conséquence, Recherche et développement pour la défense Canada (RDDC) a entrepris un projet sur la visualisation des données géospatiales dans le cadre du Programme de recherches appliquées (PRA). Le présent rapport porte sur les questions d'ergonomie associées à la visualisation des données géospatiales dans un environnement de système d'information géographique (SIG) mobile. Les travaux couverts par le présent rapport représentent la phase de délimitation du projet.

Résultats : La première phase de ce projet comportait un examen détaillé de la littérature récente sur l'utilisation des SIG mobiles. L'objectif de cette phase était d'évaluer la convivialité de ces appareils, compte tenu des tâches militaires pertinentes pour lesquelles ils pourraient être utilisés. Une recherche approfondie a été menée et 20 articles en tout ont été sélectionnés et évalués. Après avoir analysé la documentation pertinente, une liste de 32 tâches militaires opérationnelles qui pourraient éventuellement bénéficier de l'accès aux données géospatiales sur les SIG mobiles a été compilée. Ces tâches ont été réparties selon les fonctions militaires de haut niveau (p. ex., attaque, défense, patrouille). En outre, une liste de 14 exigences physiques et techniques pour l'utilisation des appareils portables dans les opérations d'infanterie a été établie.

La deuxième phase a consisté à étudier divers dispositifs de visualisation de données géospatiales. Une évaluation fonctionnelle complète des capacités des appareils SIG mobiles a été réalisée. Cette évaluation a porté sur les SIG mobiles portables, en l'occurrence des produits commerciaux (dont les téléphones cellulaires intelligents) et militaires standards. Nous avons dressé une liste des principaux dispositifs SIG mobiles et analysé leurs caractéristiques et leurs capacités d'après les manuels et les spécifications des produits demandées aux fabricants. D'après ces fonctionnalités et caractéristiques, nous avons ensuite établi une liste restreinte de 23 appareils commerciaux et de 10 appareils militaires standards en vue d'une analyse fonctionnelle plus poussée. Nous avons consulté la documentation de chaque appareil. Nous avons compilé une matrice d'évaluation pour déterminer si les appareils répondaient aux tâches opérationnelles définies à la phase 1, et aux exigences physiques et techniques. Sur une feuille de calcul, nous avons reporté les résultats de l'évaluation des produits par rapport aux tâches et aux exigences. La troisième phase du projet a comporté un atelier qui a été organisé en coordination avec la Direction des ressources terrestres (DRT) et le Projet d'équipement intégré du soldat (PEIS). L'atelier a porté sur les besoins des utilisateurs, les lacunes opérationnelles et les solutions futures potentielles. Des officiers des forces terrestres des niveaux opérationnels supérieur et intermédiaire, provenant de la DRT, du PEIS et d'autres secteurs, avaient été invités. Plus précisément, l'atelier visait un double objectif : (i) valider la liste des tâches établie et les lacunes éventuelles, (ii) discuter et prioriser les utilisations

opérationnelles pertinentes des SIG mobiles, et également définir les futurs axes de recherche. Enfin, nous avons établi, d'après les informations recueillies lors de l'atelier, un plan de recherche initial pour les études en laboratoire et sur le terrain qui porteront sur les questions d'ergonomie associées à l'utilisation des SIG mobiles pour les forces terrestres.

Importance : Le présent rapport résume les résultats d'une étude des capacités des SIG mobiles actuels et présente une analyse des questions d'ergonomie associées à la visualisation et au traitement efficace de volumes importants de données géospatiales sur des appareils portables. Le travail présenté ici contient suffisamment d'information pour définir la portée du projet de visualisation de données géospatiales, dans le cadre du PRA, notamment l'évaluation des questions d'ergonomie associées à la visualisation des données géospatiales dans un environnement de SIG mobile.

Plans futurs : Les travaux futurs dans le cadre du PRA consisteront à étudier les capacités des SIG mobiles actuels et les questions d'ergonomie associées à la visualisation et au traitement efficace de volumes importants de données géospatiales sur des appareils portables. Les domaines suivants ont été jugés prioritaires pour les recherches futures :

- Symboles
- Superpositions
- Fouillis (clutter)
- Partage de l'information cartographique
- Alarmes et alertes
- Besoins en information et filtrage
- Représentations des incertitudes
- Question « tête haute ou tête basse »
- Conception physique
- Possibilités d'exploiter l'information provenant de systèmes existants dans d'autres domaines

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1. Introduction

1.1 Background

The design of location-based technology systems is expected to play an important role in future military mission success. Accordingly, Defence Research and Development Canada (DRDC) has initiated an Applied Research Project (ARP) on the evaluation of human factors issues associated with geospatial data visualization in a mobile Geographic Information System (GIS) environment (14dk). GIS is a tool used for understanding geographical relationships which potentially could lead to more intelligent decision making. By organizing geospatial data in a unique fashion, GIS affords an operator reading a map the ability to access information pertinent to a specific project or task (ESRI, 2007). GIS can help soldiers achieve enhanced situation awareness to plan, brief, explain, rehearse and/or visualize steps or expected action of the operation as well as monitor the execution of missions (Blankenbeckler et al, 2006).

This report summarizes work conducted during the scoping phase of the ARP. Future work under this ARP will investigate current mobile GIS systems capabilities and human factors issues associated with the effective visualization and processing of large volumes of geospatial data on handheld devices. This project intends to answer the questions of:

1) What are the human factors issues associated with geospatial data visualization in a mobile GIS environment?
2) What are the limitations with using handheld mobile GIS interfaces?
3) What are the capabilities and functionality of hardware and software in the market?
4) What are the circumstances in which the Canadian Forces (CF) could benefit from a GIS system?
5) What are the best methods for evaluating human factors issues under those circumstances?

The outcome of this work will form the basis of the proposal for the second and third phases of this ARP.

1.2 Scope and objectives

The overall aim of the work reported here was to investigate the capabilities of Commercial-Off-The-Shelf (COTS) and Military-Off-The-Shelf (MOTS) mobile GIS systems and to develop a research plan for the future study of human factors issues related to infantry soldier geospatial tasks performed with these types of systems. The objectives of this work as laid out in the SOW were as follows:

1) Conduct a critical review and assessment of the basic and applied research literature, in particular the human factors literature, relevant to visualization of spatial data in a mobile Geographic Information System (GIS) environment.

2) Conduct a critical review of existing mobile GIS technology providing recommendations of the most suitable technology for further evaluation.

3) *Conduct review and assessment of Canadian Forces (CF) needs for a mobile GIS system with respect to the various contexts and circumstances in which a GIS system will provide a benefit to CF operations, and identifying the aspects of objectives 1 & 2 that meet this requirement.*

4) *Based on the outcomes of 3:*

   a) *Produce measures for the evaluation of human performance using mobile handheld systems to the dismounted soldier in contexts where such a system would be of benefit to the CF.*

   b) *Propose designs for laboratory and field experimental assessment of geospatial data visualization in mobile GIS environment in contexts where such a system would be of benefit to the CF.*

These objectives were accomplished through a number of tasks. An extensive review of recent literature on the use of mobile GIS systems was conducted. The focus of this review was on identifying military relevant tasks where mobile GIS systems could be used. The findings of this front-end analysis were then presented to operational personnel during a workshop organized by Human*systems*® in coordination with DRDC Toronto, DLR and the ISSP. Finally, a research plan for future laboratory and field studies of the human factors issues associated with the use of mobile GIS systems in a land forces environment was created.

1.3 Outline of report

There are 7 sections in this report. Section 1 is the introduction. Section 2 presents the literature search method and section 3 presents a review of the operational tasks that could involve geospatial data visualization and user requirements for mobile GIS devices. Section 4 lists technical and physical considerations. Section 5 describes the mapping process applied during the COTS/MOTS analysis. Section 6 includes details about the workshop that was conducted for gathering subject matter expert opinion, and Section 7 concludes with the research plan developed.

2. Literature Review Method

This section outlines the literature search method by providing details of keywords used and the search results obtained

2.1 Keywords

Members of the Human*systems*® research team used the keywords that were discussed with and approved by the Scientific Authority prior to starting the literature search. They are presented in Table 1.

Table 1: Keywords

Core Concept	Primary Keywords	Secondary Keywords
Geospatial	geospa*, GIS, map*, Global Positioning System (GPS), navigation, spatial, terrain, visual*	web, net, mobile.
Technological	human factors, ergonomics, data, applications, information, system, modeling, digital, tools, augmented reality	
	hardware, software, hw, sw, design, requirements, tools, services, solutions	
Mobile	handheld, hand-held, mobile, tablet, wrist, interface, Personal Digital Assistant (PDA), display	Online.
Task Analyses	task analysis, Cognitive Task Analysis (CTA), Hierarchical Task Analysis (HTA), Cognitive Work Analysis (CWA)	
Military	battlefield awareness, wayfind*, terrain navigation, route guidance, reconnaissance, platoon, orders, mission, plan*, briefing, command*, route planning	urban operations, open country terrain, in-building operations.
Social Factors	transfer, collaborat*, shar*	

For conducting this literature search, all Geospatial keywords were paired with Technological, Mobile, Task Analysis, Military, and Social Factors keywords using "AND" logic.

The following databases were included in the literature search:

- Google Scholar
- STINET
- Psych Info (which includes Human Factors)

- DRDC publication database
- NTIS
- CISTI

When keywords were searched, the following information was documented in a spreadsheet:

- Database searched (e.g., Psych Info)
- Keyword combination (e.g., geospa* AND navigation)
- Number of hits
- Number of applicable hits
- Articles downloaded
- Articles/books that require purchase, and,
- If applicable, where in the article the keywords were searched (i.e., only in the article keywords or anywhere in the article).

In addition, the literature search was augmented by having the DRDC librarian use the keywords to search military and American databases.

The Soldier Information REQuirements Technology Demonstration (SIREQ TD) had collected and analyzed a great deal of information pertaining to the mapping needs of dismounted infantry soldiers. The SIREQ project set out to define and validate the performance requirements for the future Soldier System by conducting experimentation, subject matter expert reviews, laboratory and field studies, and simulation studies. The reports from SIREQ, therefore, contained a great deal of relevant information in the form of task analyses, experimentation results and capability summaries related to command execution, target acquisition and situational awareness for the individual Canadian dismounted soldier[1]. Thus, the Humansystems team leader of the SIREQ TD hand selected the most relevant and applicable SIREQ reports for this current study.

2.2 Literature Review Results

Forty six pertinent articles were found through database searches in addition to 15 SIREQ reports and 4 reports recommended by the scientific authority. The DRDC librarian search provided an overlap with 15 articles already found, however an additional 5 were found, giving a total of 70 relevant articles.

The research team then developed some two preliminary criteria to evaluate the 70 articles. First, 'relevance' was defined as how closely the article relates to the research objectives outlined in the Statement of Work. Specifically, relevance was assigned the following 3 point scale:

- 1: Focus is on either: a) map-based operator tasks; or b) mobile geospatial technologies (anything to do with human factors issues or visualization of spatial data).

1 http://pubs.drdc-rddc.gc.ca/pubdocs/sireq_e.html

- 2: Mentioned – but not the focus – is either a) map-based operator tasks; or b) mobile geospatial technologies (anything to do with human factors issues or visualization of spatial data).
- 3: No specific mention of any of these terms, but still considered relevant.

A second criterion, 'quality', was also developed. Quality was expressed as a 3 point scale as follows:

- 1 = journal, SIREQ Report
- 2 = technical report, summary or conference paper,
- 3 = magazine article

It was possible to compile a short list of 36 relevant articles, after examination and ranking of them against the relevance and quality scales. Out of the 36 selected articles, 9 were SIREQ reports. A second examination of the 36 reports resulted in 20 articles being selected for full review. This was done by examining each article to see how well the abstracts mapped to the content and by considering all the articles rated '1' in terms of relevance and 1 and 2 in terms of quality. Out of the 20 selected articles, 7 were SIREQ reports.

A list of 32 potential tasks involving the use of mobile geospatial data asks for military operations was compiled after reading the relevant literature. These tasks were organized by high-level military functions (e.g., attack, defend, patrol) and are outlined in Section 3. In addition, a list of 14 physical and technical requirements was generated, and these are outlined in Section 4. The literature review clearly showed that limited conclusive information was available about general human factors considerations in using mobile GIS devices for military map-based tasks.

2.3 Scope and Assumptions for Literature Review

The primary objective of the literature review was not to present a generic review, but to specifically inventory military operational tasks that could require geospatial data visualization, and user requirements for a hand held mobile GIS device.

The following section presents a summary of these tasks with details about how and where mobile GIS systems could be used in support of those tasks. Many hand-held mobile GIS devices have communication capabilities (e.g., radio communications, cellular phone, text messaging). However, this project targets tasks associated with visualization of geospatial data. It is important to mention that some of the relevant communication activities, such as map-based information sharing (e.g., mission briefing with a digital map) are included since they are related to mapping activities and could involve mobile GIS devices.

Since the primary focus of the articles reviewed and information recorded was on soldier tasks that could require geospatial data visualization, the following assumptions were made:

1. An inclusive approach was taken when listing the tasks, subtasks and requirements with slight regard as to whether or not the specific requirements could be met on a mobile (versus a desktop) device. As such, it may later be determined that some requirements are not feasible on handheld devices due to power, processing speed, display size or some other limiting factors.

2. The military is an authoritarian structure involving different levels of control assigned to different ranks and levels of personnel. A general assumption was that the operators identified possessed the proper authority and autonomy to carry out the tasks as defined in the literature. Any authority issues or concerns that may be raised by providing additional functionality or devices to personnel were considered out of scope.
3. The approach taken was to focus on '**what'** information or process is required (e.g., user selectable display of entities) rather than '**how'** things should be implemented (e.g., pull down menus).

3. Inventory of Tasks for a Mobile GIS Device

This section outlines the potential geospatial map-based tasks specific to military operations. Commanding officers and section commanders would use the mobile GIS devices for different tasks than a rifleman would. Similarly, there are different tasks for a mobile GIS device depending on the state of the mission (e.g., defending, attacking, or planning) or the type of warfare (e.g., open terrain, urban). Therefore, tasks were grouped into categories of Attack (Commander, Rifleman), Defend (Commander, Rifleman), Patrol (Commander, Rifleman), Passage of Lines, Urban Warfare, Operations Other Than War (OOTW), and Mission Planning (Commander).

3.1 Attack (Platoon and Section Commanders)

For an attack, the Platoon Commander estimates cover, obstacles, position of fire, and position of the enemy (Tack & Angel, 2005). The Platoon Commander is responsible to estimate time, space, and enemy capabilities and transmit attacking intentions to subordinates. The Platoon Commander could activate remote video devices from fixed and mobile cameras to gather and record information from different perspectives and allow viewers to see detail which would otherwise be obstructed by foliage or walls. The Platoon Commander could potentially use a mobile geospatial data visualization device for tasks outlined in Table 2 (Tack & Angel, 2005; Tack et al, 2005; Tack & Colbert, 2005; Nakaza & Tack, 2005; Angel & Massel, 2005; Colbert et al, 2005a).

Table 2: Potential tasks for Mobile GIS – Platoon Commander (Attack)

Task #	Potential Geospatial Data Visualization Tasks	User Requirements for a Mobile GIS device
1	Reference imagery	Ability to load and display ground level photos and aerial photos, zoom in and out, overlay contours, roadways, features, key landmarks.
2	Reference maps	Ability to load and display maps with terrain, contours, features, roadways, vegetation (from seasonal information); key landmarks; heading; Canadian Digital Elevation Data; American Digital Terrain Elevation Data; different coordinate systems (e.g., lat/long, military grid system, Universal Transverse Mercator, British National Grid System & Irish Transverse Mercator Grid coordinates) (Tappert et al, 2001).
3	Manipulate maps	Ability to zoom in/out of maps. The rapid transition between large scale and smaller scale maps would be desired (Blankenbeckler et al, 2006); rotate the map – either auto-rotate based on the direction in which the operator is holding the device or the map can remain in the classic north up/east right (Blakenbeckler et al, 2006)[2]; scrolling/panning (i.e., moving the map up/down/left/right)[3]. Maintain legibility/discriminability - no matter the orientation or viewing conditions, map detail should be easy to read and to discriminate.

2 Wayfinding when soldiers were using maps that did not have an on-screen rotating compass proved specifically susceptible to error (Tack & Colbert, 2005).

3 Automatic scrolling may be desirable, either as the map moves with the operators' movements or as the map moves with the movements of another entity that the operator is "tracking".

Task #	Potential Geospatial Data Visualization Tasks	User Requirements for a Mobile GIS device
4	Watch Video	Display video camera feed in real time, display previous videos, activate and control video cameras remotely. Sources of video could vary (e.g., ground video and Unmanned Aerial Vehicle (UAV) video).
5	Track own location	Ability to view own location on a map or aerial photo (Krum, 2003; Tappert et al, 2001; Blankenbeckler et al, 2006).
6	Track location of blue forces	Ability to geo-reference other mobile GIS devices on a map; track location of other individual soldiers, teams or section commanders in the field; store multiple geo-references on maps; have geo-referenced messaging, have instant recognition of blue vs. red forces; provide situational awareness display where the status of section and platoon members can be identified (e.g., could include casualty locations and status of each element. Velocity as well as acceleration of blue forces could also be included, if deemed necessary (Tappert et al, 2001).
7	Track location of enemy forces	Ability to input position of red forces, and assign a level of uncertainty. The fact that the device is tracking the enemy needs to be clearly displayed so the operator is not confused into thinking he/she is looking at his/her own position (Savage-Knepsheild and Martin, 2005). Display multiple soldier positions using remote cameras, Infrared (IR) beam intrusion systems, or real time video or image clips.
8	Track location of other entities	Track location of other entities (e.g., company headquarters, medical facilities, communications centres and capabilities, ops support, assets and their maintenance schedules, intelligence information, etc,. Allow siting and interface with laser rangefinder (or laser rangefinder binocular) to display entities such as targets, obstacles, or arcs of fire. Ability to use mobile unit to create points for 3D modeling (e.g., generating a digital model of a building or a roadway intersection).
9	Insert notes and/or hand drawn overlays on the digital map	Input text, flags, markers, symbols, common warfighting symbols, enemy Group, Range, Indication, Type of fire (GRIT), and other icons. Draw plans and mission sites such as Objective Rendezvous (ORV), location of sections and sub-units, arcs of fire, location of Observation Posts (OPs) and Listening Posts (LPs), location of unattended ground sensors, location and viewing angles of video cameras, location of support weapons, platoon headquarters, attack positions, fire bases, and cut-offs; supports cut, copy, and paste of information.
10	Insert notes and/or hand drawn overlays on photos	Ability to point out features or indicate firing positions through text input, or 'post-it' note type additions. Could involve handwriting recognition software (handwriting to text);
11	Automated Target Designation and Reporting	Create targets on a digital map, network multiple hand-held units so they display the same target, allow for target status updating.
12	User selectable display of entities	Ability for clutter reduction (e.g., a commander may want to visualize only leaders, versus everyone on the battlefield), customizable filters to allow choice of information that is relevant to role and type of operation.

Task #	Potential Geospatial Data Visualization Tasks	User Requirements for a Mobile GIS device
13	Maintain awareness of device status and alarms	Provide passive/active sensor monitoring, alarm trigger, display of sensor status on a digital map or 3D virtual urban environment and geo-referenced alarms (e.g., inadvertently entered an enemy or dangerous area) (Savage-Knepshield and Martin, 2005) Sensors could be acoustic, seismic, electro-magnetic, or IR beam. Indication of the status of the device is also desired (Savage-Knepshield and Martin, 2005).
14	Distribute information to others	Ability to distribute information to dispersed units (e.g., Platoon commander enters a target on a virtual map and everyone's mobile GIS device is updated with that target) and share information to higher and lower command levels.
15	Ability for multiple people to share a common picture	Allow co-located personnel to view a single screen or multiple screens; provide ability for distributed personnel to view a common picture.
16	Facilitate mission briefing	Display video feed of commander's briefing and map/digital media simultaneously.

The tasks of the Section Commander are similar to those described above for the Platoon Commander, with some differences described below. Before an attack, a Section Commander receives orders from the Platoon Commander on probable mission, timings, direction and special instructions (Tack & Angel, 2005). The Section Commander uses map information in conjunction with the mission objective and weather to create a Warning Order for the section, indicating obstacles, terrain, boundaries, objective (enemy position), routes, likely fire base locations, and other terrain conditions such as snow and ice, rivers, and swamp. Next, a visual reconnaissance of the ground where the mission would be executed is performed. The Section Commander is responsible to give orders to section members using a map, sand box and verbal briefing (Tack & Angel, 2005).

During an attack, the Section Commander navigates by determining his own position and the distance travelled along a tactical route (Tack & Angel, 2005). The Section Commander memorizes the environment and route before the attack using a map or a 3D[4] virtual environment, and recalls it in the real world. The Section Commander may need to change the route if, for example, a new sniper area is identified. The Section Commander controls field formation of the section, reacts to enemy fire by commanding the section, determines the location (range and bearing) and strength of the enemy, sends contact reports to the Platoon Commander, and uses the map to develop and communicate an assault plan. The assault plan is typically short and concise, consisting of a map sketch detailing fire positions, fire base, and assault route (Tack & Angel, 2005).

Following that, the Section Commander adopts assault formation and confirms objective location by having fire teams line up for assault from a covert position (Tack & Angel, 2005). The assault involves fire and movement control while the assault team approaches and attacks objective. After

4 Note that with some advanced technologies a 3D virtual environment could involve a 3D holographic image or the illusion of depth through stereoscopic vision equipment. However, for a hand-held mobile GIS device, it is more likely that a 3D virtual environment would be displayed on a 2D screen using various 3D representations such as wireframe or solid modelling with shading.

the assault, consolidation involves adopting an all around defensive position and checking ammunition and casualty status. A situation report is issued to the Platoon Commander and Platoon Warrant Officer while defending against a counter attack and preparing for the next task. For an attack, the Section Commander could potentially use a mobile geospatial data visualization device for tasks as outlined in Table 2. The Section Commander has specific additional visualization tasks and associated requirements and these are outlined in Table 3 (Tack & Angel, 2005).

Table 3: Potential tasks for Mobile GIS – Section Commander (Attack)

Task #	Potential Geospatial Data Visualization Tasks	User Requirements for a Mobile GIS device
1-16	See Table 2	See Table 2
17	Plan and Revise Route	Display maps, aerial photos, terrain, boundaries, objective, and route, use route planning software to determine the optimum[5] route and develop alternative routes, save multiple routes, share and view shared routes; provide ability for the individual soldier to update the route while in the process of conducting the mission (e.g., in case of a sniper area), display bearing, distance to waypoints, type of terrain, contours of the ground, prominent features (e.g., roads, bodies of water), size of patrol (e.g., 4-man teams). Timing information could be based on the actual mode of transport planned (e.g., marching vs. Light Armoured Vehicle (LAV) as well as surface and weather conditions (Tappert et al, 2001; Blackenbeckler et al, 2006).
18	Calculate distance between locations	Calculate and display distance between GPS or map locations, between self and other entities, show bearing between two reference points; use route planning software to determine tactical route.
19	Collaborative visualization and manipulation of the operational area	Provide 3D battlefield image generation and display for multiple people, display of battlefield with entities, assault positions, enemy positions, fire base, assault routes, and other key items. Allow manipulation of the environment during a briefing (e.g., fly-through or navigate with an avatar and joystick).

At the time of writing this report, Task 19 is likely to require high-power, advanced computer technologies that are not likely to be available with the current technologies in a mobile hand-held unit. Currently a Section Commander uses a physical 3D sandbox model of the battlefield

5 "Optimum" can vary based on different criteria (e.g. stealth, direct, avoid roads, fastest, shortest, preferred or other considerations) (Blackenbeckler et al, 2006)

(constructed from sand, shrubbery, toy models etc.) to conduct a verbal briefing of the attack. In the future, however, mobile GIS technologies could allow this to be done with more accuracy since a 3D model of the terrain could be downloaded from a GIS information database and virtual models of CF equipment could be imported. Group 3D visualization of the battlefield could be done on a large screen with the Section Commander controlling the view, or by showing the same image on each hand-held unit.

3.2 Attack (Rifleman)

For an attack, a rifleman receives Warning Orders from the Section Commander and prepares for battle by considering the mission objective, special weapons, likely enemy locations, timings, and orders (Tack & Angel, 2005). A map briefing is done by the Section Commander. It is a verbal and visual concept of mission tasks using the map with critical information such as routes, objectives, own location, objective rendezvous, and obstacles. Often, orders are received through a sandbox 3D model of the battlefield and a detailed rehearsal of the mission. The briefing involves Communication Equipment Operating Instructions (CEOI), frequencies, nicknames, passwords, Line of Departure, and instructions on how the mission will be conducted.

Next, the Rifleman moves with the section and maintains field formation (Tack & Angel, 2005). The rifleman searches for targets (possible enemy fire positions) by sighting their weapon in arcs while maintaining cover and concealment and responding to their Section Commander movement and formation orders. The rifleman determines the location of the enemy, communicates the positions to commanders, and reduces or eliminates the effectiveness of enemy fire by engaging the enemy with suppressive fire. Fire teams adopt tactical positions prior to engaging in the assault. An assault team approaches and attacks the objective. After the attack, consolidation involves redistributing ammunition, adopting an all-around defensive position, and checking ammunition and equipment, and assessing casualty status.

For an attack, the rifleman could potentially use a mobile geospatial data visualization device for tasks as outlined in Tables 2 and 3. The rifleman has no specific additional visualization tasks.

3.3 Call for Fire (Forward Observer)

A call for fire may be required by the Forward Observer (FO), in consultation with the Platoon Commander. The elements of a call for fire (CFF) include sighting the enemy, calculating their position, converting their location to lat/long coordinates, and communicating the CFF request (Savage-Knepshield and Martin, 2005). The communications include the following information in the following order[6]:

- FO ID
- Warning order (WARNO)
- Target location
- Target description
- Method of engagement
- Method of fire and control

6 Elements of the Call for Fire. GlobalSecurity.org. http://www.globalsecurity.org/military/library/policy/army/fm/6-30/f630_5.htm

The FO is responsible for communicating each of these elements clearly. For a CFF, the FO could potentially use a mobile geospatial data visualization device for Tasks as outlined in Tables 2 and 3. The FO has no specific additional visualization tasks.

3.4 Defend (Platoon and Section Commander)

For defence, a **Platoon** Commander establishes mission intent, issues warning and occupation orders, consolidates platoon range cards, and optimizes and controls platoon fire (Tack & Angel, 2005). A range card is a sketch (see Figure 1) containing trench positions (150 meters of frontage) with grid position of each trench, orientation, and tactical information such as reference points, features, rendezvous, obstacles, adjacent trenches, clear areas, laneways, weapons, arcs of fire for each trench, secondary arcs of fire, trip flares, and the bearing and range to important identifiable objects (Nakaza and Tack, 2005).

When siting a platoon defensive position, the position for a trench is identified along with the associated arcs of fire, lines of sight, dead ground (places you cannot fire), obstacles, and kill zones (Nakaza and Tack, 2005). The Platoon Commander compiles the locations of many trenches, and then uses the overall picture to command sections to be in optimal positions. This is very difficult and time consuming without a mobile GIS system, and especially difficult at night, due to terrain visibility and distance estimation. Often infantry sections have to move and re-dig new trenches in the morning due to sub-optimal positioning at night.

Soldier's Day (1999, Figure 1) explains that "To make the defence more efficient, every fighting trench prepares a range card to register reference points within its arc of fire, ranges and possible future targets. The range card represents the target area, drawn as seen from above with annotations indicating distances throughout the target area. The range card gives the soldier a quick range reference and means to record target locations since it has pre-printed rings on it. A field expedient range card can be prepared on any paper the team has available. The soldier position and distances to prominent objects (i.e., easy to identify) and terrain features will be drawn on the card (as to not cause confusion during the heat of battle). There is not a set maximum range on either type of range card because the soldier may also label any indirect fire targets on his range card."

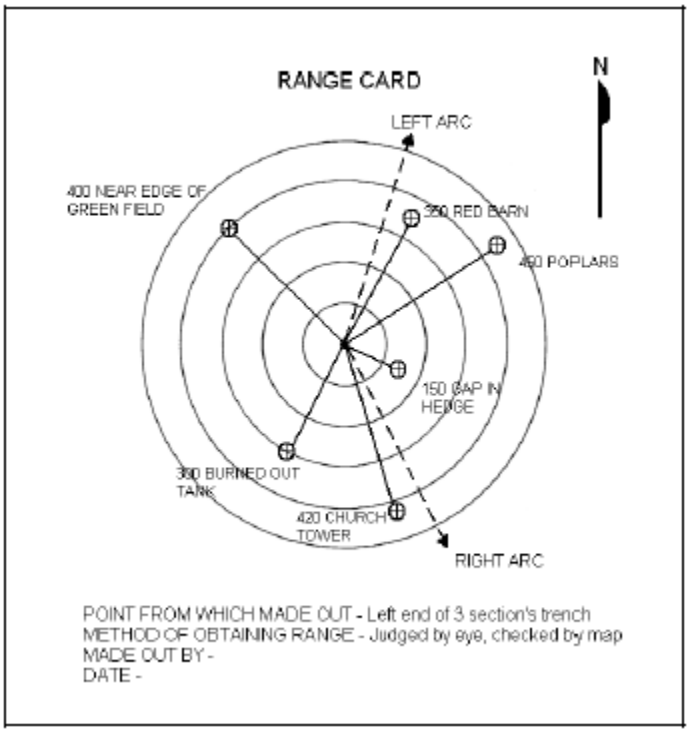

Figure 1: Range Card Example

For defence, the Section Commander receives Warning Orders from the Platoon Commander regarding the probable mission, timings, situation, reconnaissance group movement, special administration instructions, key personnel information (e.g., who has to supply rifleman for reconnaissance group), traffic control points, special weapons, digging equipment, sand bags, and engineering support (Tack & Angel, 2005). (Note: knowledge of the situation comes from the previous days/weeks activity). A Section Commander plans by considering time appreciation, confirms equipment, and performs map reconnaissance for planning trenches, camouflage and concealment.

A reconnaissance of the defensive site includes gathering terrain information (e.g., obstacles, boundaries, likely enemy routes, woods, likely weapon position, trench position) to initiate a plan for overall defensive position with specific section requirements as the focus (Tack & Angel, 2005). These requirements include arcs of fire, trench location and orientation, and special weapons position (e.g., machine guns or rockets). Next, a Section Commander prepares a range card (see Figure 1) and directs marking the field with mine tape and boundaries. The Section Commander liaises with other commanders to coordinate and create a Track Plan that involves ground indications between trenches, routes to observation posts, and routes to Platoon Headquarters.

Next, a Section Commander gives Occupation Orders to the section to occupy the defensive position (Tack & Angel, 2005). Then a Section Commander sets up signals and updates the Commanding Officer. A Section Commander conducts routines in the observation posts by observing arcs of fire, challenging people on approach and determining if they are friend or foe, controlling shift changes, and setting up radio frequencies and signals to Platoon Headquarters.

Once the position is defendable, Confirmatory Orders are received from the Commanding Officer that include detailed information on occupation, updates, open fire policy, signals set up, and the Commanding Officer's intent.

The Section Commander passes on Confirmatory Orders to the section members as needed (Tack & Angel, 2005). The Section Commander inspects Range Cards and trenches to ensure arcs are covered and makes sure trip flares and wire are recorded. The Section Commander controls the position of riflemen in their section and fire during a defensive battle, and needs to know strength in the trench.

For defence, the Platoon and Section Commanders could potentially use a mobile geospatial data visualization device for tasks as outlined in Table 2 and Table 3. The Platoon and Section Commanders have specific additional visualization tasks and associated requirements and these are outlined in Table 4 (Tack & Angel, 2005).

Table 4: Potential tasks for Mobile GIS – Platoon and Section Commanders (Defence)

Task #	Potential Geospatial Data Visualization Tasks	User Requirements for a Mobile GIS device
1-19	See Table 2 and 3	See Table 2 and 3.
20	Create and display layout of defensive position and firing arcs	Ability to display layout of defensive position (e.g., digital range card) including trench positions (150 meters of frontage), with grid position of each trench, orientation, and tactical information such as reference points, features, rendezvous, obstacles, adjacent trenches, clear areas, laneways, weapons, arcs of fire for each trench, secondary arcs of fire, trip flares, and the bearing and range to important identifiable objects. The defensive position layout could be an overlay on a map or a standalone image.
21	Consolidate multiple defensive positions	Consolidate data for multiple defensive positions, display all defensive positions on one map.

3.5 Defend (Rifleman)

For defence, a rifleman receives Warning Orders from commanders on the probable mission, timings, enemy structure (i.e., enemy strength, vehicles, uniforms, local activity), radio frequencies, codes, and passwords (Tack & Angel, 2005). A rifleman sites trenches by identifying trench position, orientation, key terrain or identifiable features, and arcs of fire to section members who will occupy the trench. A rifleman may be involved in creating the Range Card. A rifleman receives Confirmatory Orders such as situation, Platoon/Company/Battalion picture on a map with the layout of ground and friendly forces, radio frequencies, code words and passwords, timings and priority of work.

A rifleman may receive an Observation Post briefing and hand over (Tack & Angel, 2005). Key information is given to the person taking over the Observation Post including arcs of fire, prominent points, areas of concern, notes from previous patrol, running passwords, location of barriers/land lines and early warning devices. Once in an Observation Post, a rifleman scans by looking and listening for any activity in arcs, visually scan left to right or, reverse and near/middle/far distance in a random order, detecting with eyes, ears, and rifle scope, sight or binoculars. If any movement or activity is observed, a rifleman must determine if approaching party is enemy or friendly, try to identify details of strength, speed, and weapons, and call in information to the Section Commander (Tack & Angel, 2005).

During defence, the rifleman controls their own fire based on acquiring a target, rules of engagement, operating procedures, and verbal fire orders from the commander (Tack & Angel, 2005). The rifleman may be required to execute aimed shots at enemy vehicles, personnel and equipment, move to and defend a position (e.g., dash to another trench), observe the front and prepare for enemy attack. An Ammunition/Casualty report is given to the Section Commander when ammunition is required or when someone is wounded (casualty).

For defence, the rifleman could potentially use a mobile geospatial data visualization device for tasks outlined in Table 2 and 3. The rifleman has no specific additional visualization tasks.

3.6 Patrol (Platoon and Section Commander)

During a patrol, the Platoon Commander gives and receives orders, arranges resources, and determines timing, routes, possible rehearsals, signals, radio frequencies, and load capacity of people or vehicles (Tack & Angel, 2005). The Platoon Commander uses their understanding of the terrain, maps, sketches, and 3D sandbox models to brief others, explain tasks, and point out obstacles, cover, points of observation, and enemy locations.

The Platoon Commander is responsible for navigation while travelling on the route (Tack & Angel, 2005). The Platoon Commander considers the terrain, key landmarks, bearing, direction of travel, distance travelled, and compares these with the route on a map (Tack and Colbert, 2005). Typically a navigation team confirms their position with GPS. A platoon may need to stop at a recognizable landmark in order to avoid an obstacle or an enemy location. Navigation is much harder at night because it is difficult to see the terrain and avoid detection due to noise, flashlights, or backlighting of electronic displays.

During a patrol, the Section Commander gives and receives orders regarding the probable mission, timings, direction, time to move and special instructions (Tack & Angel, 2005). The Section Commander prepares route cards with detailed instructions for navigation during the patrol. The Section Commander may need to navigate and determine their own location on a map with or without GPS, determine the direction of travel, navigate using a bearing, and navigate by determining the distance traveled. Patrolling may involve conducting detailed reconnaissance of enemy strength, equipment, and routines. The Section Commander briefs subordinates using maps and/or sketches (Tack & Angel, 2005).

The Section Commander is responsible for route planning (e.g., determining the best route for reconnaissance), controlling movement of a section, adjusting positions to react to changes during reconnaissance, and controlling positions of the fire base just prior to assault (Tack & Angel, 2005).

For patrol, the Platoon and Section Commanders could potentially use a mobile geospatial data visualization device for tasks as outlined in Table 2 and Table 3. The Platoon and Section

Commanders have specific additional visualization tasks and associated requirements for the patrol role and these are outlined in Table 5 (Tack & Angel, 2005).

Table 5: Potential tasks for Mobile GIS – Platoon and Section Commanders (Patrol)

Task #	Potential Geospatial Data Visualization Tasks	User Requirements for a Mobile GIS device
1-19	See Table 2 and 3	Requirements as outlined in Table 2 and 3 in addition to night use, night camouflage.
22	Navigate outdoors en route	Provide ability to display bearing for navigation during a patrol, confirm current position in real-time by GPS. Provide situational awareness display for considering long term route (e.g., position in 2 minutes) and ability for the individual soldier to update the route while in the process of conducting the mission.
23	Consolidate multiple routes	Consolidating data for commander to view multiple routes, store multiple routes, ability to display or not display routes

3.7 Patrol (Rifleman)

For patrol, a rifleman receives Warning Orders on the probable mission, timings, direction, points of reconnaissance, as well as what to prepare (Tack & Angel, 2005). The orders could involve route cards, sand-box briefings, and rehearsal instructions. A rifleman prepares a route card for the patrol commander. The route card includes key written leg information that may be represented by a string on a sandbox model. The rifleman uses a map to create individual legs for the route with instructions from the patrol commander which involve start and end grid with some general comments.

The rifleman receives Operation Orders, including situation information, detailed instruction on mission and execution, timings, routes, radio frequencies, nicknames, coding, and all actions (e.g., escape and evasion, medical, POW, instructions if lost) (Tack & Angel, 2005). The rifleman is responsible to navigate and determine their own location on a map, and navigate using distance traveled. The rifleman signals patrol members to control movement. The rifleman also confirms objectives, conducts reconnaissance, and returns to objective rendezvous. The rifleman challenges people as they approach and identifies them as friend or foe. The rifleman secures and occupies the objective rendezvous, occupies sniper positions, and conducts Observation Post routine as outlined in section 3.5.

The rifleman communicates detailed reconnaissance information to patrol commanders using notes and sketches (Tack & Angel, 2005). The rifleman builds a picture based on what two or more members see during reconnaissance, and gives patrol or attacking commanders more information including tactical advice for a successful raid. The rifleman communicates reconnaissance information to the patrol base and escorts the raid patrol commanders to the objective and briefs them using a sketch. The patrol could also lead to an attack scenario, involving tasks such as a hasty ambush, approach, and assault.

For patrol, a rifleman could potentially use a mobile geospatial data visualization device for tasks as outlined in Table 2, Table 3, and Table 5. The rifleman has no specific additional visualization tasks.

3.8 Passage of Lines

A passage of lines is an operation where "a force moves forward or rearward through another forces combat position with the intention of moving into or out of contact with the enemy". This is one of the most dangerous tasks a unit can perform, as there is a high potential for fratricide if lower units are not provided with accurate and detailed information (Blankenbeckler et al, 2006).

The Section or Platoon leader starts the planning process by integrating range cards and other information together to create sketches of the passage. The leader must consolidate sketches and send them up to their Commander, who then continues the consolidation upward. These sketches should include manoeuvre overlays showing the locations of passage points and expected timings; an obstacle overlay with the precise locations of obstacles; and, a fire support overlay detailing restricted fire lines, no fire areas and free fire areas at minimum. Additional overlays containing relevant intelligence information, medical facilities, etc may also be desired. The passing units must also agree on a time or distance from the handover line at which each unit becomes responsible for its own support. Eventually a Common Operating Picture (COP) is created detailing engagement capabilities, dead space, target plans, obstacle plans and passage lanes. Leaders must review the plans to ensure they are realistic, feasible and understood. This can be facilitated by simulating a mission rehearsal on a handheld device. Leaders are then required to communicate their mission with appropriate individuals.

For conducting a passage of lines, CF personnel could potentially use a mobile GIS device for tasks as outlined in Table 2 to 5. There are no specific additional visualization tasks.

3.9 Urban Warfare

In urban warfare, CF personnel perform attack, defend, patrol, and Operations Other Than War tasks (OOTW) tasks as outlined in previous sections (Tack & Colbert, 2005). They also use Blue Force Tracking, which uses GPS information to locate and track friendly entities. In military symbology, the color blue is typically used to designate friendly forces while red is used for enemies, and green or yellow are used for neutral forces (Tack et al, 2005). CF personnel could also use Automated Target Designation and Reporting which is a system where the Platoon Commander communicates to dispersed personnel by designating a target on a digital map, and Riflemen and Section Commanders are able to see the target, attack the target, and report to the Platoon Commander by updating the status of the target.

For urban warfare, CF personnel could potentially use a mobile GIS device for tasks outlined in Table 2 to 5. Also, they have specific additional visualization tasks and associated requirements and these are outlined in Table 6 (Tack & Colbert, 2005).

Table 6: Potential tasks for Mobile GIS (Urban Warfare)

Task #	Potential Geospatial Data Visualization Tasks	User Requirements for a Mobile GIS device
1-23	See Tables 2 to 5	Requirements as outlined in Tables 2 to 5
24	Navigate Indoors	Provide ability to track 3D location (latitude, longitude, and elevation or floor number) inside a building, track own position and position of mobile (other soldiers with GPS) and stationary entities, display floor layouts, display and navigate through 3D models of buildings (inside and outside) during pre-mission virtual navigation and in real-time.
25	Navigate on Urban Streets	Provide ability to display 2D overhead layout of urban streets, create, display, and navigate through 3D virtual environments of urban streets during pre-mission virtual navigation and in real-time; display roadmaps/streetmaps (e.g., Google maps overlaid with street names), show legend, information on types of buildings (e.g., hospital, school, church).

3.10 Operations Other Than War (OOTW)

For OOTW, the Platoon Commander passes information of enemy location and enemy Group, Range, Indication, and Type of Fire (GRIT) (Tack & Angel, 2005). The Platoon Commander commands Fighting in Built Up Areas (FIBUA) by determining the position of Section Commanders, assigning sections to clear streets or buildings, monitoring information on casualties (i.e., what happened? where? how?), planning and ordering the evacuation of casualties, setting up rendezvous points and rally points, and giving orders on what to do if individuals get separated. The Platoon Commander may need to give orders for reacting to hostile crowds, gather information (photos and tapes for negotiation) and perform negotiations (possibly with an interpreter). The Platoon Commander also updates maps by showing the authorized route for travel, new hazards, and anything else that has changed.

The Section Commander leads short formation moves (5-10 km distances), uses binoculars in the Observation Post to observe terrain, plots routes with GPS if maps are not accurate, conducts small foot patrols to find essential elements of information (i.e., number of houses), inspects sites to confirm state of events and inventory, performs surveillance, counts vehicles and vehicle build-up, and determines amount of traffic and type of traffic (e.g., number of logging trucks) (Tack & Angel, 2005). In case of enemy detection, the Section Commander determines the location of enemy fire and determines the open fire policy for a reaction. The Section Commander liaises with local civilians since people might come to their section during a patrol for supplies (wood, clothes etc.) and need help with problems. The Section Commander plans routes for escorts and convoys, and might also be involved with minefield evacuation (coordinate a helicopter to evacuate casualties from a minefield). The Section Commander navigates by wayfinding through all terrain conditions including open country, urban streets, and inside buildings.

The Rifleman receives Warning Orders regarding weapons, positions, vehicles, reconnaissance information, timings, kit, liaison with locals, and ROE (Rules of Engagement) (Tack & Angel, 2005). Orders may involve a briefing with an accurate map of sector. The Rifleman may need to liaise with local civilians, and to do so typically Riflemen want to remain friendly, cooperative, and neutral. The Rifleman establishes checkpoints and checkpoint operations such as cutoff, search, traffic control, and security. The rifleman establishes road barriers (e.g., dragon teeth) and searches vehicles for weapons and proper license plates. The rifleman also escorts VIPs after conveying the setup of the escort, routes and sniper locations. Communications are coordinated with reconnaissance personnel. Detailed escort orders would include timings, frequency, snipers locations, security, dispatch personnel, routes and alternative routes. During an escort there is as little communication en-route as possible. The Rifleman works in a team to cordon and search, secure rooms, search houses and buildings, remove weapons and determine security. The rifleman determines target locations, quantity, range, movement, and weapons. The rifleman detects mines and conveys mine awareness and information on clearing ground.

For OOTW, the Platoon Commander, Section Commander, and Rifleman could potentially use a mobile geospatial data visualization device for tasks outlined in Tables 2 to 6. Also, they would have specific additional visualization tasks and associated requirements and these are outlined in Table 7 (Tack & Angel, 2005).

Table 7: Potential tasks for Mobile GIS – OOTW

Task #	Potential Geospatial Data Visualization Tasks	User Requirements for a Mobile GIS device
1-25	See Tables 2 to 6	Requirements as outlined in Tables 2 to 6
26	Mark-up inaccurate maps	Ability to markup maps, overlay correct information, block out inaccurate information.
27	Logistics management	Ability to count and track available inventory, use a barcode scanning interface, display map of stores, track distribution of ammunition and weapon maintenance.

3.11 Mission Planning (Platoon and Section Commander)

For mission planning, a Platoon Commander conducts time-appreciation analysis by determining future possibilities based on how far and fast a platoon's soldiers and vehicles can move, and how far and fast the enemy can move (Nakaza and Tack, 2005). A Platoon Commander also conducts weather effects analysis to see if the near-term weather could affect performance of a mission. A Platoon Commander also uses digital planning software (e.g., ArcExplorer, Sextant, Delorme, and Half-Life) to plan and optimize troop movements, and rehearse proposed operations with 3D virtual tours of the battlespace (Angel & Massel, 2005). The Platoon Commander develops an understanding of the mission environment through route knowledge and survey knowledge, and monitors their defensive position by displaying soldier positions on a virtual map (Angel & Massel, 2005). The Platoon Commander plans positions for Observation Posts and Listening Posts according to the terrain (Colbert et al, 2005a). These are typically in a high ground area, not dug-in, and do not have range cards. During a mission, the Platoon commander may need to adapt a

mission plan or develop an alternative route based on changes in mission conditions or new information. The Platoon Commander may also need to brief troops on a mission remotely via a video link (Colbert et al, 2005b).

For Mission Planning, the Platoon Commanders has specific additional visualization tasks and associated requirements and these are outlined in Table 8 (Nakaza & Tack, 2005; Angel & Massel, 2005; Colbert et al, 2005a, 2005b).

Table 8: Potential tasks for Mobile GIS (Mission Planning)

Task #	Potential Geospatial Data Visualization Tasks	User Requirements for a Mobile GIS device
28	Time appreciation	Use time appreciation software to predict potential movements of own platoon and enemy.
29	Weather effects analysis	Ability to download current and predicted weather conditions for the area of interest, identify potential hazards on a digital map.
30	Integrate GIS info with digital planning software	Support 2D or 3D topographical images, satellite image, aerial photos, UAV imagery, and GPS tracking to digital planning software tools (e.g., ArcExplorer, Sextant, Delorme, and Half-Life).
31	Visualize battlespace options and plans	Employ user-manipulated or fly-though animations of 3D virtual battlespace for mission rehearsal, planning, and briefing.
32	Plan storage	Ability to store mission plans for future retrieval and reference.

The following tasks were also mentioned in the literature that could benefit from the use of GIS systems. However, with no further detail on the subtasks, personnel or requirements involved they were not expanded upon in the previous sections.

- Artillery/Mortar guidance
- Medical support – The locations of casualties as well as the closest medical facility and route planning could be useful for dismounted soldiers. A mobile system could also provide information automatically to the targeted facility about the condition (e.g., heart and breath rates) of the person soon to be arriving (Tappert et al, 2001).
- Imagery Gathering – images can be automatically geo-referenced and linked to intelligence reports, as well as other images. For example, there is already an iPhone/iTouch application that reads images of street signs and links them to related intelligence information (Sutherland, 2009).

3.12 Summary

A summary of the aforementioned tasks, and which requirements apply to each task is included in Annex 1.

4. Technical and Physical Requirements

In addition to the task-based considerations in the previous sections, a number of technical and physical considerations were also identified through the literature. They are included below in Table 9.

Table 9: Technical Considerations

#	Technical Consideration	Description
a	Size	Height, length and width of the device and screen.
b	Weight	Overall weight including batteries.
c	Stowage	When not in use, the handheld must be stowable in a secure location on the operator.
d	Power	Enough power must be supplied to the device in order for proper functioning; rechargeable (e.g., through field replaceable batteries, LAV-chargeable, solar or bio-movement powered); power levels need to be communicated to the operator; ability to add power while the unit is in operation (Huffman et al, 2008). Battery life must be longer than the mission.
e	Ruggedness	Meeting vibration, temperature, shock, drop, dust and water protection standards (i.e., MIL-STD-810F, IP Code (e.g., IP54) for water and dust protection) (Huffman et al, 2008); amount of field maintenance required should be low (i.e., it should be easy to clean and not require delicate part changes or special tools).
f	Standards	Meets applicable military standards (e.g., MIL-STD-810F, Environmental Test Methods and Engineering Guidelines; Night Vision Imaging Systems (NVIS) compatible, MIL STD-3009) (Huffman et al, 2008, Tappert et al, 2001; International Protection Rating).
g	Means of Operator Input	Input types (e.g., soft/hard keyboard, tilt sensors (Hinckley et al, 2000), buttons, touch screen, stylus required or not); function with either left or right hand (Huffman et al, 2008); gloved hand operations (Savage-Knepshield and Martin, 2005); connections (e.g., USB, RS32, connection to range finder).
h	Output forms	Output could be visual, auditory, and/or tactile (Elliott et al, 2006).
i	Processor Power	Determines the speed of operation and therefore the sophistication of software able to be used.
j	Memory	Memory is related to the number of software programs able to be used and the sophistication of the software. It involves RAM (data storage for the operating system and active programs) and ROM (data or programs that are stored until needed).

#	Technical Consideration	Description
k	Data supported	Types of data (e.g., raster, vector, digital-elevation data (Abdalla and Niall, 2007), how the data is presented (e.g., 2D v.s 3D) (Lif et al, 2006), and accuracy (e.g., level of GPS accuracy) (Abdalla and Niall, 2007).
l	Lighting	Usability in all lighting conditions, including night.
m	Camouflage	Should not visually reveal the soldier's location to the enemy (Savage-Knepshield and Martin, 2005). Depending on the operation, this could be day or night.
n	Security	Secure system - password, network security, encryption of information, monitor access, capability to quickly zero a system if it fell into enemy hands.

5. Review of Existing Mobile GIS Technology

Once the front-end analysis was completed and approved by the Scientific Authority, a product investigation was undertaken for Commercial (including smart phones) and Military Off-the-Shelf (COTS/MOTS) hand-held[7] mobile GIS devices. An internet search was conducted, and product information was gathered from 21 potential MOTS companies. The analysis focused on technical specifications, and user manuals for the hand-held mobile GIS products. Five companies responded by providing direct and relevant information on their products of interest. The information found on the internet was combined with information found through solicitation, and the searching was determined to be sufficient for 23 commercial devices (including 6 smart/cell phones), and 10 MOTS devices. Functional analysis of the literature was thoroughly conducted for each product where specific attention was paid to how the device met the military operational tasks and physical and technical considerations. The information gathered in this stage was entered on a spreadsheet where the products were mapped against the tasks and considerations generated during the front-end analysis. Technical information (e.g., battery life) was entered as a quantity. User requirements were entered as Yes, No, or with relevant notes (e.g., some requirements could be met if software was developed).

The findings of this review can be found in Annex 2. Note in the listing in Annex 2 the user requirements developed in the front-end analysis (summarised in Sections 3 and 4 above) have been reorganized according to the following categories in order to provide more logical groupings of tasks:

- Mapping Functions (simple display of layers, location coordinates etc)
- Editing Functions (adding new features or textual input to the map - mark-up, pin-point, comments, etc)
- Data Processing and Analysis Functions (additional processes beyond basic mapping)
- Housekeeping Functions (internal device functionality, status, and security)
- Visualisation Options (2D, 3D, video, etc)
- Field Operational Factors

Note also that the reorganization of categories caused some of the tasks and technical considerations to be split, resulting in a change in the number of tasks and capabilities from 46 to 50.

7 As per the Statement of Work, the focus of this project was on hand-held mobile GIS systems only. This meant that larger tablet computers and mini-notebooks were considered out of scope.

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6. Workshop

A workshop was conducted on October 27th, 2009 in Ottawa, Ontario, Canada. The focus of this workshop was to discuss and prioritize operationally relevant uses for mobile GIS systems, as well as outline future research areas. Participants from Defence Research and Development Canada (DRDC) Toronto, the Integrated Soldier System Project (ISSP), Director Soldier Systems Project Management office, Department of Defence Director Science and Technology Land, and Human*systems*® Incorporated attended the workshop. The input from such a variety of participants resulted in an extensive discussion of all operationally relevant capabilities. A workshop plan was created that details participants, schedule of events, and other administrative details. This plan can be found in Annex 3, and a summary of the minutes from the event can be found in Annex 4.

The workshop started out with general round table introductions, a review of the objectives for the day as well as future goals of the broader ARP. Human*systems*® then presented the task/capabilities listing work that had been completed thus far in the project. Further explanations about the process, literature reviewed and hardware systems mapped were also noted.

The discussion then turned towards human factors issues, focusing on contextual considerations, operational experience, and the general needs of the users. The discussion included current systems, desired systems as well as areas of research for further investigation. At the end of the workshop, these issues were prioritized by the workshop participants.

Once the workshop was completed, Humansystems reviewed the information collected and high level experimentation areas were identified. These areas were then explored in greater depth in order to recommend specific research projects for consideration. These research areas are laid out in the following section.

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7. Research Program and Platform Recommendations for Mobile GIS

This section lays out operationally relevant human factors experimentation areas related to the use of mobile geospatial information systems (GIS) by dismounted soldiers in the Canadian Forces (CF). The long term goal of the research program is to support the development of human factors requirements for mobile GIS technology that improves soldier situation awareness (SA), and decreases (or, at minimum, does not increase) the physical, perceptual and cognitive workload at the individual and team level of the operator. If done thoughtfully, this will lead to improved command and control, planning and execution of CF missions.

7.1 Scope of the Proposed Research Program

The developed/proposed research plan is based upon two sources of information: (i) Analysis conducted by the Human*systems*® team based upon existing documentation of soldier's information requirements for mobile map usage (Sections 2 and 3); (ii) Information obtained from the workshop (workshop details can be found in Section 6 and Annex 3; workshop minutes are in Annex 4) of subject matter experts (SMEs). Thus, the list of areas identified below is a combination of those identified prior to – and discussed/confirmed – at the workshop as well as those that arose organically during the workshop. The specific focus of the current project meant that not all potential issues identified were pursued, since they were judged to be not operationally relevant experimentation areas. However, the analysis conducted shows that there appears to be an extensive list of areas for possible research related to military mobile GIS systems. In arriving at a recommended list, topics that were overtly grounded in current system functionality (e.g., the effectiveness of the Micro-DAGR) were *not* included. This was done to maximise the usefulness of the project results, as focusing on current systems could limit the applicability of the project to future systems. Similarly, broad issues applicable to all military systems and processes (e.g., how to effectively apply lessons learned, training requirements) were excluded also. Instead, the goal has been to identify broader areas of research that are relevant *only* to mobile GIS systems.

A final note is that in organising and filtering the information obtained, we have tried to place the major emphasis on issues that would be most appropriate for an ARP. We understand that the focus of an ARP is on original research with the goal of developing generic concepts, models and possibly guidelines and databases that would potentially apply beyond the land force operational context. This contrasts with many of the issues identified by operational personnel in this project, which may involve specific analyses, investigations, or development of technological applications/solutions, to specific operational needs (e.g., the analysis of specific GIS information requirements by different command levels). Such issues have traditionally tended to be more suited to a Technology Demonstration Project (TDP) than an ARP.

Accordingly within each area of research outlined below, we have first listed the ARP themes followed by a sub-section, where appropriate, outlining the research areas that would be more suitable for a TDP.

7.2 List of Areas for Research

The following areas are discussed as potential themes of human factors research related to mobile GIS systems. They are listed in order of priority based on brief listings of preferred research areas by workshop attendees:

- Symbology
- Overlays
- Clutter
- Map Based Information Sharing
- Alarms and Alerts
- Information Requirements and Filtering
- Uncertainty Representations
- Head up vs. Head down issues
- Physical Design
- Leverage from Other Domain GISs

In each of the sections below, we provide a general introduction to the major issues associated with each topic, followed by a more detailed outline of specific research themes.

7.3 Symbology

Text, images, and general marking are used as symbols to represent a variety of objects, including their location as well as separating different geographical features on mobile GIS systems. In military settings, much attention, training and standardization has been put into symbology development and implementation. Specifically, the North Atlantic Treaty Organization (NATO) stipulates symbology standards for mapping symbols in terms of their appearance and application. While much research has gone into these standards, the use of these symbols on the smaller mobile systems has not been systematically investigated or well documented. Pixel limitations, colour, familiarity, appropriateness of icons and issues of scaling all influence the selection of the most appropriate symbols for any system. These issues need to be researched and understood specifically in the context of mobile GIS systems for military soldiers.

Note: Studies looking at the use of NATO symbols on small screen mobile systems have recently begun at DRDC Toronto.

Research Themes

1. This phase could begin with a literature review focused on map-based symbology used on mobile (i.e., small screen) systems. Priority should be placed on those systems used in military settings. The results of this project would be a guideline on symbology use and an identification of where experimentation may be required to cover gaps in existing knowledge.

2. A second area of investigation is exploring the specific requirements for symbology in an operational context. This would cover not only the design and mode of displaying individual symbols, but also how data and information are integrated together and combined when zooming in/out on the system and how this data integration impacts associated symbology (see Overlays for

more information on this, Section 7.3). The outcome of this initial phase would be guidelines and principles for symbology design with respect to factors such as: a) size, b) colour coding, c) the number of usable contrast levels, d) automatic desegregation of cluttered symbols and e) the means of attaching and displaying ancillary information (and annotations) to base symbology. The research would need also to take into account contextual issues such as the visibility of symbology under the wide range of illumination conditions that occur in the operational theatre.

TDP Issues

Analysis needs to be conducted of the land force operational requirements in order to create an *inventory* of required symbols that would complement the existing symbology set.

7.4 Overlays

Overlays are a key functional component of a GIS system. It is through implementing different layers of geographic features that insights from spatial analysis are incorporated into the operator's decision making process. Different methods of combining the data together can be used. A series of layers (field-class raster data) can be superimposed on top of each other in certain cases. Alternatively, map objects (object-class vector data) can be combined together, and also overlayed on raster data (Abdalla and Niall, 2007).

When used in isolation, each overlay may contain a great deal of data that may or may not be relevant to the operator at any given time. Through adding layers on top of each other, zooming, panning and moving within a map, an operator can begin to tailor and manipulate the data to suit his/her current information requirements. When properly designed, overlays can ensure that the operator is presented with relevant information for the immediate operational context. There are a number of human factors issues that arise in the implementation of multiple overlays on a mobile GIS:

- Overlay selection: How does an operator access and view the data? Are there automated systems that know that in X scenario, operator Y would want to see Z, or is there an exhaustive list of options that the operator must search through? It would be unfortunate for a solder to overlook access to available, but hidden, information due to an oversight (e.g., soldier does not see the sewer system which is being used by the enemy as an attack path).
- Clutter: (note that in this section we are dealing with the clutter that potentially arises from the use of multiple overlays. More generic issues concerning clutter are dealt with in the next section.) As an operator zooms in/out and moves through a spatial representation, the overlays must also zoom and move. If overlays are displaying sparse information on large screens, then seeing all the information simultaneously will not be a problem. Operationally, this is rarely the case as soldiers are required to use small mobile screens with large amounts of information, thus leading to cluttered displays. Even information that is easily displayed when zoomed in becomes cluttered on top of itself when zoomed out.

Research Themes

1. There is a need to develop principles on how to aggregate overlays meaningfully. This would serve to ensure that data are represented in a manner that will enable information to be readily extracted from a composite set of overlays. This research will need to address not only the extraction of information integrated from the data available in different layers, but also how to

maintain the separation of salient, within-layer information. In addition, such principles will also need to address issues of where data segregation will be required to prevent unwanted blending across layers, both from visual and cognitive (i.e. information extraction) perspectives.

2. Innovative methods for the functional implementation of layers (for example "morphing"[8]) will need to be explored and empirically evaluated.

TDP Issues

A. Analysis will be required to gain a better understanding of the operational use of overlays, including who uses which overlays and when.

B. The functional capabilities of devices to display the required operational data should be investigated to document and understand which data type (raster vs. vector) is best for which type of overlays.

C. The appropriate level of automated, semi-automated and user-initiated overlay selection needs to be determined for a given set of operational circumstances and associated information needs (including any differences associated with level of command) and (ii) the specific method(s) to be used for operator-initiated overlay selection.

7.5 Clutter

By clutter we mean either the visual or cognitive discrimination difficulty that arises when multiple graphic elements are rendered on a display. The effect of clutter is to impair the ability of the user to search, locate and extract a specific piece of data or information. Clutter may arise either within a data layer or from the result of multiple layers being displayed. Issues of clutter reduction (i.e. information segregation) resulting from multiple layers were addressed in the previous section. Here, we outline issues relating to within-layer clutter.

Within-layer clutter may arise for the following reasons:

- Symbology may be poorly designed and take too much space on the display.
- Color coding may be applied inappropriately making salient information difficult to find.
- Data are not filtered appropriately and too much data are supplied to meet a specific operational information need.
- There is an absence of smart algorithms to allow neighbouring (and potentially overlapping symbology) to maintain an appropriate level of segregation.

Research Themes

1. One major research approach would be to determine whether clutter reduction methodologies in existence for large screen displays can be generalised and applied to the smaller mobile GIS format. To the extent that they may not, innovative methods that are automated or user-initiated for clutter reduction will need to be investigated. The goal would be to create standardized guidelines for mobile GIS systems for clutter reduction, to identify symbology formats that are resistant to clutter, and to develop algorithms for clutter reduction based upon a user's visual and cognitive information requirements. Further, given that not all operational configurations may be

8 Morphing is the smooth transformation of one image into another using digital tweening. http://en.wiktionary.org/wiki/morphing

anticipated in advance, methods by which operators may individually be able to rapidly reduce clutter in the field should also be looked at.

7.6 Map Based Information Sharing

A major complication with the switch from analog maps to digital maps is how information is shared. When soldiers are all standing around a paper map, with either a map in their hands or on a table, it is easy to reach out and point to different sections, describe planned attack manoeuvres or explain what can be expected in different areas. Physical indicators (e.g., pins, post-it notes, etc) can be placed on the map marking specific details about particular locations. Everyone is 100% sure that they are looking at the proper map and at the proper location on that map. The potential for this sharing process to become more complex and confounded arises when soldiers are working with mobile GIS systems. While it would still be possible for them to pull out a paper map for discussions, this would be an incredible waste of time as they would not only have to go through the process of taking out the map, and unfolding it, but also the cognitive demanding task of orienting themselves into the paper map and then locating the area on the map they are interested in.

Sharing information between and within sections needs to be efficient, easy and accurate. This means that soldiers need to ensure that they are looking at the same picture. This will partly involve detailed verbal communications, but should also be facilitated by mobile GIS software. The sharing of maps, specific overlays, screen image captures, etc should be made automated to ensure the proper details (i.e., which overlays are included, where on the map, etc.) are easy to share and communicate.

Research Themes

1. Analysis is required to determine what kind of technical solutions are applicable for ensuring that a commonly scaled and centred map is both easy to facilitate from a user's perspective as well as technologically feasible. This will involve investigating the levels of interoperability needed as well as the technology requirements for each level. The shared map will be more than simply a scaled location; additional information (e.g., overlays) will also have to be included to ensure a common picture is communicated.

2. Soldiers need to share mark-ups on maps. Currently, this is done with paper, pins or post-it notes. Specific analysis of the best way of visually indicating, initiating and receiving this type of information should be conducted. This will include research into technological implementations as well as human factors issues with this type of functionality. Successful approaches and techniques used for the sharing of mark-up information in other non-military application environments and display formats should be investigated with a view to determining which approaches may be applied and adapted for the mobile GIS environment.

7.7 Alarms and Alerts

Alarms and alerts will be required on mobile GIS systems to bring user's attention to various conditions. These alarms and alerts may be triggered by a range of circumstances, including the following:

- **Physical Status**: The mobile GIS device itself will be required to track its own physical status in a number of areas, alerting the operator of potential problems with the device. This includes battery levels, internal errors, etc.

- **Connections:** The majority of GIS information to be integrated and displayed on the device will come from external connections that the mobile GIS system must initially create and then maintain. Connections to satellites for GPS data, communications with other soldiers, links to higher command, etc will all be implemented through various technical protocols. Problems with these connections will have to be flagged to the operator. This will include lost connections as well as when jamming is suspected.
- **Information Alerts:** When a device is connected to external sources, certain pieces of information may be deemed critical with the operator desiring an alert. This includes, for example, emails, plan execution issues, and timing slippage/changes. Information alerts could also be triggered by specific operationally relevant circumstances, for example, recently found locations of IEDs, soldiers not moving as expected, new enemy contact detected by sensor.
- **Navigation Errors**: As operators are navigating within and between their areas of operation, there will be certain information that should be brought to their attention. This includes warnings when they are approaching suspected dangerous areas (e.g., mine fields), major changes in mission execution compared to the mission plan (e.g., H hour not going to be met by own or flanking sections), significant deviations from planned path, etc.

The alarm stimuli implemented for each of these different alarms and alerts can be conveyed by various modalities. Visual, auditory, and tactile (e.g., vibration) would be the most obvious choices for mobile military GIS systems. Operational issues may complicate modality selection, for example, any tactile implementations will have to provide enough of a vibration to be felt through the multiple layers of clothing, while not being sensed by any enemy units. Furthermore, there may be technical complications brought on by desired implementations. For example, high power consumption imposed by the selected method (notably vibration) will have to be weighed against operational benefit. Though it is likely that visual and auditory are the most likely candidate modalities for alarm implementation in the short term, as power supply technology improves (i.e., batteries continue to get smaller and more lightweight) vibration, and possibly other modalities, may be deemed more desirable.

In planning an alarm system it should be noted that alarms are unlikely to occur in isolation, with one alarm arising in a calm environment and being cleared before additional (possibly) conflicting alarms are raised. Instead, multiple alarms may occur in quick succession, each with varying levels of importance (e.g., an email alert is not as high a priority as entering a potential mine field) in the middle of a war zone. Multiple alarms and alerts, if not properly implemented, can lead to confusion and inappropriate choice of actions. Excessive alarms can cause desensitisation to alarming, leading to reduced trust in the device and potential disabling of the nuisance alarm function.

The design and implementation of an alert system will need a disciplined approach to ensure that the likely combination of alarms that could occur in operations is mutually compatible and that an appropriate method for alerting the operator is selected.

Research Themes

1. Mode of implementation. The goal will be to determine the appropriate sensory properties for the many different alarm types and priorities. The operational context, in which the mobile GIS system will be used, will be a prevalent aspect of this study, as it plays heavily into factors such as: the frequency of alarms, complications of clearing of alarms, and overlapping occurrence of alarms. Each alarm priority area and each alarm type will need a unique implementation to reduce confusion between alarms. Technical limitations will also play a role in this phase, as power levels

and other hardware and software issues may constrain the desired implementation. The goal of this research will be to create guidelines specifying, for example, the type, number, mode of implementation optimal clearing methods, need for local customization for alarms on military mobile GIS systems. This phase will involve a significant level of experimentation to be conducted in a laboratory/simulation environment to allow for a full manipulation of all of the experimental variables and alarm parameters of interest. (Note: this would be too difficult and costly to achieve in a field setting).

2. Another area is to examine guidelines and best practices for alert system design in other relevant and analogous application domains, and then determining the degree to which those existing solutions may be workable in a military mobile GIS context.

3. Not withstanding the outcome of (2), there is a need to explore innovative methods for implementing alarms and alerts that may be practically applied to mobile GIS. This will begin by determining the psychometric properties of suitable candidates to evaluate their cognitive impact and salience, both in isolation and with respect to other (and existing) sensory alerting techniques. This will lead to laboratory studies to evaluate how the sensory and cognitive properties of alarms are related to their perceptual and cognitive "attention getting" properties.

4. A more generic issue is how to structure meaningfully the cognitive alarm space. This includes the following issues:

- dimensionality – how many different sensory and cognitive dimensions need to be considered to define an appropriate alarm space.
- number of levels – what are the meaningful number of psychological levels for alerting versus alarming with respect to issues such as immediacy and saliency.
- interruptability – how to ensure that alarms are timely and delivered when the operator needs them but do not inappropriately interrupt critical ongoing tasks.

5. It may be useful to examine, the degree to which rules for the "etiquette" of human based interruption may applicable. This would include evaluating the research on computer aided-prompting systems to see how issues of the timing of an automated aid have been addressed.

6. Finally, a validation study should be conducted to verify and validate that the guidelines and associated alarm implementations are appropriate for operational use. This final phase should involve field experiments using a prototype mobile GIS system with a more or less complete alarming and alert functionality. This prototype will need to be deployed in a realistic operational scenario, possibly during regular training activities.

TDP Issues

A. Alarm inventory. The focus of this would be to document the information to be relayed in alarms and alerts. The desired output for this phase will be an inventory of alarms. This study should include universal listings of alert requirements for all operators in different command levels and roles.

B. Alarm prioritization/customization. The specific priorities associated with each of the alarms in the inventory must be identified. The number of appropriate priority levels to apply in a field setting will be a critical area for research, as existing guidelines and data may not be applicable to the operational environment.

C. The degree to which the alarms will need to be customized and displayed to different levels of the command hierarchy will also need to be analysed. The need for consistency in approach to alarm implementation across all command levels will be a particular challenge when considering alarm priorities and selection. What may be a high priority alert at one level of command, may be a lower priority at a different level.

7.8 Information Requirements and Information Filtering

The first stages of the current project set out to filter, clarify and document the information requirements of dismounted soldiers. As detailed in previous sections, soldiers require different information for different tasks. Their information requirements also vary based on the type of mission they are on, the type of environment they are in (e.g., arctic vs. desert) and their location (e.g., urban vs. rural). While the current project provided a good start on documenting these needs, building on these information requirements, and how they vary, will need to be continued. Information about how users interact with, add to, augment and perform other annotations will also be of interest.

A number of specific operational information needs that have not been adequately addressed in current systems were raised during the workshop. These include:

- Determining the best design approach to combine information for siting.
- The need to display information on individual soldiers – e.g., their health state (including both health records and current vital signs), and status of weapons and equipment.
- The ability to show when the data associated with a map attribute has changed (e.g., to allow a soldier to query a shop and find out the name of the owner, children, and the date updated).
- How to effectively pass information from one brigade to another during CF deployment transitions (i.e., each time troop masses are sent to/from Canada).
- Gaining access to local demographic trends and any available local census information.

In addition to determining a way to collect together all of this information, incorporate it into communications systems and effectively display it on a GIS system, there is also a need to filter the information at different command levels and possibly by roles, since too much information disseminated widely will impair the C2 process. For example, higher command should not be constantly monitoring the lowest levels of command, and lower levels do not always need to see the highest levels. Requirements on how access to information is controlled or filtered across command levels have not been satisfactorily articulated to date.

Research Themes

1. One research theme is the evaluation of existing modes of annotation used in other relevant and comparable systems to determine what might be suitable candidates for use in a mobile GIS environment. This could be conducted through laboratory studies to determine whether the modes are suitable for the mobile GIS environment, particularly considering operational constraints of dismounted soldiers.

2. Another proposed area is the development of principles concerning how annotations are implemented, particularly with respect to how this might be accomplished through layers or other techniques.

TDP Issues

A. An analysis of the operational mobile GIS information requirements by command level and role would be useful. This would result in an inventory of the minimal and optimal map content data for operators at various command levels and positions. Documenting variableness in the required positional accuracy based on mission type, location, etc. will be an important aspect of this. For example, higher accuracy is generally required for urban operations, while lower positional accuracy is required for locations that are not as built-up. This research would also include everything from weapons status, to owners of commercial enterprises, and families in specific houses.

B. There needs to be research into the means by which GIS data will be accessed and displayed (this is also tightly linked to issues of clutter and overlays). Communication protocols, users' interactions, and interface design will all need to be optimized. Human factors principles should be used to design initial concepts which should then be evaluated with soldiers to determine their perceived effectiveness, usefulness, and usability.

C. One implication of providing detailed information to dismounted soldiers is that they are able to compare maps/GIS data with reality and conduct their own error analyses, accuracy assessments and information validations while in a particular location. Current authority structures may prevent them from having the ability to actually make those changes in the databases, requiring them to instead communicate change information up through their chain of command. This may take up unnecessary time and resources. Instead some governing rules should be designed that will allow soldiers at various levels of command the tools to rapidly annotate changes/errors/etc. efficiently through their mobile GIS platform, thus ensuring important information is shared instantaneously with others. This project will require heavy involvement and influence of high level military personnel.

D. In parallel with defining these rules, the technological implementation of how soldiers will be able to add, change or delete attributes of the GIS data will need to be created. Proper interfaces, communications links and algorithms will need to be researched and designed, as well as validated through experimentation. Initial trials can take place on desktop systems, and later trials on prototype mobile GIS systems.

7.9 Uncertainty Representation

Any implemented mobile GIS within the Canadian military will be relying on multiple sources of information to populate it. These various sources will be reporting an extremely large quantity of data, at different levels of accuracy and timeliness (for example, spatial data accuracy is easier to determine than intelligence information accuracy). Thus, as GIS technology is integrating the data sources together to provide information, there will be variable levels of certainty and uncertainty about particular pieces of information. The 'certainty' about information is affected by a number of factors:

- **Type of information**: Some pieces of information are inherently easier for CF personnel to be certain of compared to other pieces of information. For instance, the presence of a shop located at corner C may be more certain than the presence of a roadside bomb at corner C.
- **Significance of the information:** The significance of any single piece of information is determined by many things, notably the actions to be taken based on that information. For instance, the fact that the owner of a particular store is a member of a terrorist organization

means that a different set of actions are associated with interacting with the owner compared to other non-terrorist store owners.

- **Source:** Some sources of information have higher levels of accuracy compared to other sources. For example, the visual identification by a CF member using his/her in-line weapons sight has a higher level of accuracy then information sourced using the more unreliable off-bore weapon sight.
- **Time lateness**: No matter how accurate the information was when it was reported or entered into the system, changes over time can render this information less certain. Some information is inherently more dynamic that other forms of information, and will therefore be more affected by time progression. For example, the reported location of an enemy HQ at location X is less likely to be affected by small time progressions than the location of a single enemy operator walking along the street at time Y. Still, at some point the location of the enemy HQ can also be deemed out of date and uncertain.

It is important to know the degree of certainty of, for example, the location reported for enemy factions, improvised explosive devices (IEDs) or simply the reported road surface quality. As discussed in the workshop, there may be a general tendency for soldiers to assume that what is shown on a GIS screen is true and accurate. The issue, then, is how to represent uncertainty in a manner that is salient to the viewer. It should be noted that in the naval domain, a project thrust looking into some of these issues has begun.

Research Themes

1. A major research focus should be how to best implement certainty/uncertainty information. This would focus on the interface between the systems and the soldiers, determining the best ways to display the certainty information given the context of operations, including how to represent potential multiple sources of uncertainty and how many certainty levels are operationally relevant and meaningful. Basic research is required to gain a better understanding of how uncertainty information can be intuitively mapped onto an individual's mental model of the reliability of displayed data.

TDP Issues

A. An analysis of the information types for which it is the most critical to have certainty data should be conducted. This phase would rely on operational requirements, data from experienced soldiers, as well as an exploration of errors in operation to understand the crucial pieces of information most in need of certainty information.

B. Another phase should focus on the types of uncertainty associated with different data sources. This phase would require a deep understanding of the inter-relatedness of type, significance, timing, and sources of information as well as other factors that can contribute to certainty. From there, various rules, algorithms and software logic programs should be developed and tested in order to generate the appropriate categories and delineations between certainty levels.

7.10 Head up vs. Head down issues

This represents an area of great uncertainty in the operational context since there is no directly relevant parallel to draw upon in current operations. The current analog is a soldier's use of a map and compass for which they need specific training to ensure that they are still maintaining the

appropriate level of environmental vigilance. However, the potential for having a large amount of salient information readily available in hand raises the question of how can soldiers maintain their battlefield SA, while at the same time trying to augment what they are seeing with information available on the GIS. Certainly, the potential exists for operators to spend more time heads-down looking at the GIS, than they do currently with paper maps. While this may to some extent be a training rather than a research issue, some human factors issues deserve exploration.

Research Themes

1. One research theme is investigating how to rapidly represent "change" when the soldier transitions from a heads-up to a heads-down perspective. A soldier's first question when looking at a tactical map of the battlefield, after a prolonged period of head-up operation, might be "what has changed", i.e., what important things need to be brought a soldier's attention.

2. In order to maintain a consistent mental representation of the real world and displayed information, some consideration may need to be given to the perspective of the GIS displayed data – whether it should be track up, north up or, if stationary, the immediate directional perspective. This will involve evaluating the applicability of existing research on orientation perspective with other map use applications and determining whether there are unique characteristics of the mobile GIS environment which would influence the adoption of the principles and practices that have evolved in these other, relevant application environments[9].

3. A related research issue is the effect lags in updating a map's orientation may have on the accuracy of information extraction and the development and maintenance of battlefield situation awareness.

TDP Issues

A. Looking ahead, as GIS systems start to be fielded in operational use, analyses will need to be conducted of those circumstances where attention to the GIS may be compromising the maintenance of battlefield situational awareness. Depending on what is found, this may result in a need for improved design or changes to training and guidance for GIS usage.

7.11 Physical Layout[10]

There are various form factors for mobile systems, ranging in size from larger tablet style laptops to the smallest cell phones. Depending on the size and layout of these mobile devices, there is also a range of input options for how the operator interacts with and inputs information to the device:

- Stylus – A digital pen that the operator uses to select, write and draw on an input pad on the mobile device.
- Touch – Instead of using a stylus, the operator uses a finger to select, scroll, etc.

9 The SIREQ TD provides a starting place for this research.

10 It should be noted that the issue of the physical layout of the device was seen as a low priority for attendees at the workshop. They expressed the belief that it is the responsibility of device manufacturers to determine the input method and form factor. However, we believe that optimal human factors design in these areas will be critical to the actual usability of a mobile GIS device.

- Scroll wheel/trackball – For scrolling, users can use a scroll wheel (usually bi-directional) or a trackball (moves in any direction). Selection is made my depressing the wheel/ball.
- Keyboard – The size of the keyboard can range from full size (as found on small laptops or notebook computers) to thumb sized.
- Buttons – In addition to a keyboard, devices may also have a numerical keypad or other buttons that the user must depress to select.
- Tilt/Motion/Location – Location sensors (e.g., GPS, inertial), gravity sensors, and accelerometers (which measure tilt) can be integrated together to 'sense' the location, orientation and other physical movements of a device. Users can then, for example, tilt to scroll through a list.

In researching appropriate input methods it should be noted that input devices are commonly used in combination, e.g., buttons, track wheel and keypad; or touch screen, tilt/location; etc. Generally, the output of information is limited to visual screens that are an integrated part of the mobile GIS device; however, sound, vibration and ports connecting to other external devices (e.g., printer) are also commonly implemented output options.

In addition to the size and input options, a CF mobile GIS device will also need to be "carried" by the operator. The device could be wrist mounted, stored in a pocket (e.g., on the leg or chest), integrated into a weapons system (e.g., visual information on a weapons sight and then a keyboard on the weapon), or some other means of carriage.

Research Themes

1. There is a need to determine an appropriate range of form factors and screen sizes to determine optimal, or minimum and maximum, physical dimensions for operational use. Analysis needs to be conducted of the advantages of larger display sizes with respect to issues of zooming, panning and clutter. Trade-off analysis should be conducted using appropriate map-based tasks.

2. Approaches to the design of input configurations will need to be studied under typical and worst case operational conditions. These input options should explore the effects of uniforms (e.g., gloves), motion, temperature (e.g., do buttons stop working below certain temperatures, etc.), power requirements, handedness (left versus right), to determine which input options are suitable for mobile GIS systems in CF operations. The goal will be to develop guidelines either for requirements specification or to be used as heuristic criteria for evaluating COTS devices.

TDP Issues

A. The influence of factors such environmental lighting and how the device is carried and device format will need to be examined in field trials.

7.12 Leverage from Other Domain GISs

A number of other domains also utilize mobile GIS systems and interfaces which could serve as fruitful sources of information and ideas for military systems. While some specific research into other domains has already been mentioned above, it may be worthwhile to expend general effort to learn from the experience of these other domains and incorporate any advantages and concepts that they may offer into future military systems. A number of specific domains were discussed at the workshop as having potential contributions. These included:

- Emergency Response Organizations – This includes emergency medical service (EMS) providers, police officers and fire responders. In many North American cities, these organizations have put a great deal of time, money and thought into creating GIS infrastructures that respond quickly, efficiently and effectively to a wide variety of emergencies.
- Police Perpetrator Locators: In addition to responder devices, there are other GIS programs that allow data about different police incidents to be collected together where potential patterns, linkages, locations, etc are brought to the attention of the analyst. This type of system is believed to assist in locating those suspected of multiple offenses. For example, a system could be created based on lessons learned from the police systems to locate and determine the perpetrator of IEDs or other terrorist activities in CF areas of operation.
- Gaming systems: Commonly, today's soldiers are joining the CF with years of gaming experience (Nintendo, computer, Xbox, etc). A desire was expressed during the workshop to look to gaming systems and select visual cues and interface design concepts that are applicable to military GIS systems. While these implementations may not necessarily be the "best", the experience and understanding that soldiers already have with these systems is significant. This includes how uncertainty information, alarms and alerts as well as friendly/enemy locations are displayed to the player. There are obvious downfalls with porting these concepts directly from the gaming industry into military systems without any regard for current system functionality. For example, certain colours have definitive connotations, as in NATO Standard Symbology.

Other domains include search and rescue and the transportation industry. This is not meant to be an exhaustive list.

Research into these other domains would look to address the following questions:

- Applications – What do these other groups use their mobile GIS systems for? What are the common errors?
- Database structures and connection types – How is the backend of their system structured? How is information transferred to mobile systems? Are their networks meeting the speed and data exchange requirements of the users effectively?
- Security – How do they prevent security breaches?
- Ways to combine/present information together – What common interface patterns are effective? Are there specific design ideas used to present information that the CF would require?

The above is not intended to be an exhaustive list, but is simply meant to initiate some consideration of possible areas that could be explored.

Research Themes

1. A first step would be to identify domains where mobile GIS systems are currently being used, and select those domains that have procedural, contextual, or other overlapping characteristics with military operations. There is potential for many domains to be identified as having concepts to be borrowed for military GIS. This project would not require any lab or field based experimentation. It would instead focus on the analysis of systems, documentation, and data collected from creators/maintainers and users of GIS systems in these various domains.

2. Alternatively, a focused research project could be conducted to look at one or more specific information requirements that have been identified as not being met effectively in current military systems (e.g., alarms). Other domains would then be reviewed to see how these aspects are implemented and what design concepts would be effective for military use. These design concepts should be tested using soldiers with mobile GIS prototypes to determine the viability of their transfer.

3. Rather doing a focused research project as detailed above, a more formal gap analysis could be conducted. Essentially, this gap analysis would look more exhaustively at the needs of the CF, identifying gaps, and then searching for possible solutions implemented in other domains. This research could be focused at the technical level (e.g., what power is required to meet operator vibration requirements) or at the operational level (e.g., how do other systems display current orientation).

7.13 Summary of Research Areas

The table below summarizes the different research theme areas that have been identified above, separating those that are more suited to ARPs (left side) and TDPs (right side).

Table 10: Summary of Research Areas

ARP Issues	*Category*	*TDP Issues*
Guideline on symbology use	Symbology	Inventory of required symbols
Symbol integration in an operational context		
Overlay aggregation principles	Overlays	Operational use of overlays
		Data types and display requirements
Innovative methods of overlay implementation		Automation levels and methods for operator overlay selection
Investigate if large screen clutter reduction methodologies apply to the smaller mobile GIS format	Clutter	
Sharing of common picture	Map Based Information Sharing	
Markings on maps		
Ideal alarm implementation	Alarms and Alerts	Alarm inventory
Determine mobile alarm guidelines		
Innovative alarm exploration		Alarm prioritization and customization
Research cognitive alarm space issues		
Validation Study		Command level alarm variability
Review existing annotation modes	Information Requirements and Filtering	Command level information requirements
		GIS data access, including the development and updating of Military Data Standards
Develop annotation principles		Authority for change/annotation
		Technical implementation of change/annotation

ARP Issues	*Category*	*TDP Issues*
Ideal uncertainty information implementation	Uncertainty Representations	Determine critical uncertainty information
		Document uncertainty of data sources
Best 'change' representations	Head up vs. Head down issues	Impact of mobile GIS on battlefield situation awareness
Optimal orientation		
Research data lag impact		
Optimal form factor and screen size	Physical Design	Field studies of operational factors
Optimal input method		
Identification of related domains	Opportunities to leverage information from existing systems used in other domains	
Focused review of specific area of mobile GIS		
Gap analysis		

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Annex 1 – Summary of Visualization Tasks and Military Tasks

The following summary table maps the potential geospatial data visualization tasks with the military tasks.

Table 11: Summary of tasks and requirements

Task #	Potential Geospatial Data Visualization Tasks	Attack (Cmd)	Attack (Rifle-man)	Call for Fire (FO)	Defend (Cmd)	Defend (Rifle-man)	Patrol (Cmd)	Patrol (Rifle-man)	Pass of Lines	Urban War-fare	OOTW	Msn Plan (Cdr)
1	Reference photos	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
2	Reference maps	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
3	Manipulate maps	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
4	Watch Video	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
5	Track own location	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
6	Track location of blue forces	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
7	Track location of enemy forces	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
8	Track location of other entities	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
9	Insert notes and/or hand drawn overlays	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Task #	Potential Geospatial Data Visualization Tasks	Attack (Cmd)	Attack (Rifle-man)	Call for Fire (FO)	Defend (Cmd)	Defend (Rifle-man)	Patrol (Cmd)	Patrol (Rifle-man)	Pass of Lines	Urban War-fare	OOTW	Msn Plan (Cdr)
	on the digital map											
10	Insert notes and/or hand drawn overlays on photos	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
11	Automated Target Designation and Reporting	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
12	User selectable display of entities	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
13	Maintain awareness of device status and alarms	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
14	Distribute information	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
15	Ability for multiple people to share a common picture	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
16	Facilitate mission briefing	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
17	Plan and Revise Route	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
18	Calculate distance between	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Task #	Potential Geospatial Data Visualization Tasks	Attack (Cmd)	Attack (Rifle-man)	Call for Fire (FO)	Defend (Cmd)	Defend (Rifle-man)	Patrol (Cmd)	Patrol (Rifle-man)	Pass of Lines	Urban War-fare	OOTW	Msn Plan (Cdr)
	locations											
19	Collaborative visualization and manipulation of the operational area	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
20	Create and display layout of defensive position and firing arcs				✓	✓			✓	✓		
21	Consolidate multiple defensive positions				✓				✓	✓		
22	Navigate outdoors en route						✓	✓	✓	✓	✓	
23	Consolidate multiple routes						✓		✓	✓	✓	
24	Navigate Indoors									✓	✓	
25	Navigate Urban Streets									✓	✓	
26	Mark-up inaccurate maps										✓	
27	Logistics										✓	

Task #	Potential Geospatial Data Visualization Tasks	Attack (Cmd)	Attack (Rifle-man)	Call for Fire (FO)	Defend (Cmd)	Defend (Rifle-man)	Patrol (Cmd)	Patrol (Rifle-man)	Pass of Lines	Urban War-fare	OOTW	Msn Plan (Cdr)
	Management											
28	Time appreciation											✓
29	Weather effects analysis											✓
30	Integrate GIS info with digital planning software											✓
31	Virtual 3D tours of battlespace											✓
32	Plan storage											✓

Annex 2 – Mobile GIS Capabilities and Products

Here is a list of all the handheld devices reviewed for this project. Below, the capabilities developed in Section 3 of this report are mapped onto each device.

GIS Systems

1. Casio MPC-701-M30E
2. Casio IT-600
3. DAP Microflex 8640B
4. Duratek 3100
5. Garmin Rino
6. Garmin Colorado
7. General Dynamics Itronix Duo-Touch II
8. Garmin Rino
9. Garmin Colorado
10. General Dynamics Itronix Duo-Touch II

SmartPhones

1. Apple iPhone
2. Blackberry Smartphone
3. Cassiopeia E-105
4. Hewlett Packard (HP) iPAQ 910 Smartphone
5. Motorola Clutch i465
6. Palm Pre

MOTS

1. Black Diamond Switchback
2. Cobham IDSS system - SDTP, SDTT
3. DRS Technologies, SELEX LRT-440 WPC (Italian "Soldato Futuro")
4. EADS Warrior 21
5. Elbitsystems (Israel) Military Tactical Computer
6. L-3 Communications LDT II
7. Northrop Grumman Soldier Link System (SLS)
8. OSI Geospatial / Raytheon DC4S product family, Hand-held for dismounted infantry: Assaulter. "COTS hardware with embedded GPS. e.g., Trimble Nomad rugged PDA"
9. Rheinmetall IC4U
10. Rockwell Collins DAGR

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GIS Systems

Casio MPC-701-M30E

Housekeeping Functions (internal device functionality, status, and security)		
1	Maintain awareness of sensor status and alarms	SW
	(comments)	
2	Plan storage	SW
3	Development Environment	Windows 2000
	Can additional programmable software be downloaded?	Y
Mapping Functions (simple display of layers, location coordinates etc)		
4	Reference maps	Y
	(comments)	SW required for vegetation, DTED, and different formats
5	Track own location	SW
6	Track location of blue forces	SW
	(comments)	
7	Track location of enemy forces	SW
	(comments)	
8	Track location of other entities	SW
9	Navigate outdoors en route	SW
	(comments)	
10	Manage multiple routes	SW
11	Navigate Indoors	SW
	(comments)	
12	Navigate on Urban Streets	SW
	(comments)	
Editing Functions (adding new features or textual input to the map - mark-up, pin-point, comments, etc)		
13	Manipulate maps	Y
14	Insert notes and/or hand drawn overlays on the digital map	SW
	(comments)	
15	Insert notes and/or hand drawn overlays on photos	SW
	(comments)	
16	Mark-up inaccurate maps	SW
Data Processing and Analysis Functions (additional processes beyond basic mapping e.g. calculations, route planning automation)		
17	Automated Target Designation and Reporting	SW
18	Distribute information to others	SW
19	Ability for multiple people to share a common picture	Approx 4 people could view the screen at once, unit could be passed around, or same image displayed on many units
20	Facilitate mission briefing	SW
21	Plan and Revise Route	SW
	(comments)	
22	Calculate distance between locations	SW
23	Consolidate multiple defensive positions	SW
24	Create and display layout of defensive position and firing arcs	SW
25	Logistics management	SW

26	Weather effects analysis	SW
27	Integrate GIS info with digital planning software	SW
28	Processor	Transmeta Crusoe TM5800 @ 800 MHz
29	Memory	128MB RAM
	Expansion?	USB, PC card slot, CF card slot
30	Data Supported	?
	GPS level of accuracy	?
31	Range Finders	Possibly could be added in ports
32	Barcode Scanners	Could be added
Visualization Options (2D, 3D, video, etc)		
33	Reference photos	Y
	(comments)	SW required for overlays
34	Watch Video	SW
	(comments)	
35	User selectable display of entities	SW
36	Collaborative visualization of the operational area	SW
37	Time appreciation	SW
38	Visualize battlespace options and plans	SW
39	Built-in Camera - Single shot	Could be added in ports
40	Built in Camera - Video	Could be added in ports
Field Operational Factors		
41	Camouflage	Likely an option
	Night	N
42	Size	24.7cm x 22.1 cm x 2.6 cm
43	Weight	1.4 kg
44	Stowage	?
45	Power	Li-Ion, requires charger
	Battery Life	?
46	Ruggedness / Meets standards	?
	Waterproof	no
	Dirt/Sandproof	no
	Heat Resistant	40 C
	Cold Resistant	0 C
	Field Maintenance	Cleaning is possible, parts would just be a unit replacement
47	Means of Operator Input	10 buttons and touch screen
	Gloved hand operation	Y
	Ports	USB, RJ11
48	Output	TVT colour LCD SVGA 800x600
	Screen size	21.3 cm (diag)
49	Security	Passwd at power ON
50	Readable in all Lighting Conditions	Y

Casio IT-600

Housekeeping Functions (internal device functionality, status, and security)		
1	Maintain awareness of sensor status and alarms	SW
	(comments)	
2	Plan storage	SW
3	Development Environment	Windows CE 5.0
	Can additional programmable software be downloaded?	Y
Mapping Functions (simple display of layers, location coordinates etc)		
4	Reference maps	Y
	(comments)	SW required for vegetation, DTED, and different formats
5	Track own location	SW
6	Track location of blue forces	SW
	(comments)	
7	Track location of enemy forces	SW
	(comments)	
8	Track location of other entities	SW
9	Navigate outdoors en route	SW
	(comments)	
10	Manage multiple routes	SW
11	Navigate Indoors	SW
	(comments)	
12	Navigate on Urban Streets	SW
	(comments)	
Editing Functions (adding new features or textual input to the map - mark-up, pin-point, comments, etc)		
13	Manipulate maps	Y
14	Insert notes and/or hand drawn overlays on the digital map	SW
	(comments)	
15	Insert notes and/or hand drawn overlays on photos	SW
	(comments)	
16	Mark-up inaccurate maps	SW
Data Processing and Analysis Functions (additional processes beyond basic mapping e.g. calculations, route planning automation)		
17	Automated Target Designation and Reporting	SW
18	Distribute information to others	SW
19	Ability for multiple people to share a common picture	Approx 2 people could view the screen at once, unit could be passed around, or same image displayed on many units
20	Facilitate mission briefing	SW
21	Plan and Revise Route	SW
	(comments)	
22	Calculate distance between locations	SW
23	Consolidate multiple defensive positions	SW
24	Create and display layout of defensive position and firing arcs	SW
25	Logistics management	SW
26	Weather effects analysis	SW

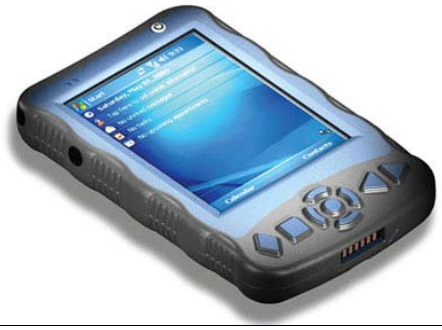
27	Integrate GIS info with digital planning software	SW
28	Processor	Intel PXA270 @ 520MHz
29	Memory	64 MB RAM, 128 MB FROM
	Expansion?	miniSD slot for memory
30	Data Supported	?
	GPS level of accuracy	?
31	Range Finders	Possibly could be added in ports
32	Barcode Scanners	built-in laser scanner: 0.127 mm resolution
Visualization Options (2D, 3D, video, etc)		
33	Reference photos	Y
	(comments)	SW required for overlays
34	Watch Video	SW
	(comments)	
35	User selectable display of entities	SW
36	Collaborative visualization of the operational area	SW
37	Time appreciation	SW
38	Visualize battlespace options and plans	SW
39	Built-in Camera - Single shot	y - built in 1 mega pixels
40	Built in Camera - Video	Could be added in ports
Field Operational Factors		
41	Camouflage	Likely an option
	Night	N
42	Size	16.6cm x 8.2cm x 2.3cm
43	Weight	290 g
44	Stowage	?
45	Power	Li-Ion, requires charger
	Battery Life	11 hours
46	Ruggedness / Meets standards	No standard, drop test on concrete from 1.2 m
	Waterproof	somewhat: IP54
	Dirt/Sandproof	somewhat: IP54
	Heat Resistant	50 C
	Cold Resistant	-10 C
	Field Maintenance	Cleaning is possible, parts would just be a unit replacement
47	Means of Operator Input	21 Buttons / Touchscreen
	Gloved hand operation	Y
	Ports	Bluetooth, Infrared IrDA 1.3, USB,
48	Output	TFT colour LCD
	Screen size	9.4 cm (diag)
49	Security	SW
50	Readable in all Lighting Conditions	Y

DAP Microflex 8640B

Housekeeping Functions (internal device functionality, status, and security)		
1	Maintain awareness of sensor status and alarms	SW
	(comments)	
2	Plan storage	SW
3	Development Environment	Windows CE 5.0
	Can additional programmable software be downloaded?	Y
Mapping Functions (simple display of layers, location coordinates etc)		
4	Reference maps	Y
	(comments)	SW required for vegetation, DTED, and different formats
5	Track own location	SW
6	Track location of blue forces	SW
	(comments)	
7	Track location of enemy forces	SW
	(comments)	
8	Track location of other entities	SW
9	Navigate outdoors en route	SW
	(comments)	
10	Manage multiple routes	SW
11	Navigate Indoors	SW
	(comments)	
12	Navigate on Urban Streets	SW
	(comments)	
Editing Functions (adding new features or textual input to the map - mark-up, pin-point, comments, etc)		
13	Manipulate maps	Y
14	Insert notes and/or hand drawn overlays on the digital map	SW
	(comments)	
15	Insert notes and/or hand drawn overlays on photos	SW
	(comments)	
16	Mark-up inaccurate maps	SW
Data Processing and Analysis Functions (additional processes beyond basic mapping e.g. calculations, route planning automation)		
17	Automated Target Designation and Reporting	SW
18	Distribute information to others	SW
19	Ability for multiple people to share a common picture	Approx 4 people could view the screen at once, unit could be passed around, or same image displayed on many units
20	Facilitate mission briefing	SW
21	Plan and Revise Route	SW
	(comments)	
22	Calculate distance between locations	SW
23	Consolidate multiple defensive positions	SW
24	Create and display layout of defensive position and firing arcs	SW
25	Logistics management	SW
26	Weather effects	SW

	analysis	
27	Integrate GIS info with digital planning software	SW
28	Processor	Intel Xscale PXA270 @ 520 MHz
29	Memory	128 MB RAM, 128 MB Flash
	Expansion?	CF Flash card slot type I, SD memory card slot, USB memory
30	Data Supported	?
	GPS level of accuracy	?
31	Range Finders	Possibly could be added in ports
32	Barcode Scanners	Y - optional integrated 1D or 2D barcode scanner
Visualization Options (2D, 3D, video, etc)		
33	Reference photos	Y
	(comments)	SW required for overlays
34	Watch Video	SW
	(comments)	
35	User selectable display of entities	SW
36	Collaborative visualization of the operational area	SW
37	Time appreciation	SW
38	Visualize battlespace options and plans	SW
39	Built-in Camera - Single shot	Could be added in ports
40	Built in Camera - Video	Could be added in ports
Field Operational Factors		
41	Camouflage	Y
	Night	N
42	Size	23cm x 18.5cm x 5cm
43	Weight	1.1 kg
44	Stowage	?
45	Power	Internal, rechargable
	Battery Life	2-4 working days
46	Ruggedness / Meets standards	Y: MIL-STD 810F
	Waterproof	Y: IP67, MIL-STD-810F
	Dirt/Sandproof	Y: IP67, MIL-STD-810F
	Heat Resistant	50 C
	Cold Resistant	-20 C
	Field Maintenance	Cleaning is possible, parts would just be a unit replacement
47	Means of Operator Input	Touch screen, full alphanumeric keypad
	Gloved hand operation	Y
	Ports	USB, RS-232, RJ45
48	Output	1/2 VGA, STN colour LCD with backlighting
	Screen size	16.5 cm (diagonal)
49	Security	SW
50	Readable in all Lighting Conditions	Y

Duratek 3100



Housekeeping Functions (internal device functionality, status, and security)		
1	Maintain awareness of sensor status and alarms	SW
	(comments)	
2	Plan storage	SW
3	Development Environment	Windows CE Mobile 2005
	Can additional programmable software be downloaded?	Y
Mapping Functions (simple display of layers, location coordinates etc)		
4	Reference maps	Y
	(comments)	SW required for vegetation, DTED, and different formats
5	Track own location	SW
6	Track location of blue forces	SW
	(comments)	
7	Track location of enemy forces	SW
	(comments)	
8	Track location of other entities	SW
9	Navigate outdoors en route	SW
	(comments)	
10	Manage multiple routes	SW
11	Navigate Indoors	SW
	(comments)	
12	Navigate on Urban Streets	SW
	(comments)	
Editing Functions (adding new features or textual input to the map - mark-up, pin-point, comments, etc)		
13	Manipulate maps	Y
14	Insert notes and/or hand drawn overlays on the digital map	SW
	(comments)	
15	Insert notes and/or hand drawn overlays on photos	SW
	(comments)	
16	Mark-up inaccurate maps	SW
Data Processing and Analysis Functions (additional processes beyond basic mapping e.g. calculations, route planning automation)		
17	Automated Target Designation and Reporting	SW
18	Distribute information to others	SW
19	Ability for multiple people to share a common picture	Approx 2 people could view the screen at once, unit could be passed around, or same image displayed on many units
20	Facilitate mission briefing	SW
21	Plan and Revise Route	SW
	(comments)	
22	Calculate distance between locations	SW
23	Consolidate multiple defensive positions	SW
24	Create and display layout of defensive position and firing arcs	SW
25	Logistics management	SW
26	Weather effects	SW

	analysis	
27	Integrate GIS info with digital planning software	SW
28	Processor	Samsung S3C 2440, 520 MHz
29	Memory	128 MB RAM
	Expansion?	?
30	Data Supported	?
	GPS level of accuracy	?
31	Range Finders	Possibly could be added in ports
32	Barcode Scanners	Could be added
Visualization Options (2D, 3D, video, etc)		
33	Reference photos	Y
	(comments)	SW required for overlays
34	Watch Video	SW
	(comments)	
35	User selectable display of entities	SW
36	Collaborative visualization of the operational area	SW
37	Time appreciation	SW
38	Visualize battlespace options and plans	SW
39	Built-in Camera - Single shot	Could be added in ports
40	Built in Camera - Video	Could be added in ports
Field Operational Factors		
41	Camouflage	Y
	Night	N
42	Size	12.1cm x 7.6cm x 1.9cm
43	Weight	150 g
44	Stowage	?
45	Power	Li-Ion, requires charger
	Battery Life	?
46	Ruggedness / Meets standards	"drop tested"
	Waterproof	somewhat: IP54
	Dirt/Sandproof	somewhat: IP54
	Heat Resistant	?
	Cold Resistant	?
	Field Maintenance	Cleaning is possible, parts would just be a unit replacement
47	Means of Operator Input	Touch screen, some control keys
	Gloved hand operation	Y
	Ports	SC slot for SDIO
48	Output	QVGA
	Screen size	8.9cm diag
49	Security	SW
50	Readable in all Lighting Conditions	Y

Garmin Rino

Housekeeping Functions (internal device functionality, status, and security)		
1	Maintain awareness of sensor status and alarms	N
	(comments)	
2	Plan storage	N
3	Development Environment	
	Can additional programmable software be downloaded?	N
Mapping Functions (simple display of layers, location coordinates etc)		
4	Reference maps	N
	(comments)	Not able to load custom maps
5	Track own location	Y
6	Track location of blue forces	Y
	(comments)	Only geo-reference of other mobile GIS devices and geo-referenced messaging
7	Track location of enemy forces	N
	(comments)	
8	Track location of other entities	N
9	Navigate outdoors en route	Y
	(comments)	Heading, bearing, real-time GPS
10	Manage multiple routes	N
11	Navigate Indoors	N
	(comments)	
12	Navigate on Urban Streets	N
	(comments)	
Editing Functions (adding new features or textual input to the map - mark-up, pin-point, comments, etc)		
13	Manipulate maps	Y
14	Insert notes and/or hand drawn overlays on the digital map	N
	(comments)	
15	Insert notes and/or hand drawn overlays on photos	N
	(comments)	
16	Mark-up inaccurate maps	N
Data Processing and Analysis Functions (additional processes beyond basic mapping e.g. calculations, route planning automation)		
17	Automated Target Designation and Reporting	N
18	Distribute information to others	N
19	Ability for multiple people to share a common picture	Approx 2 people could view the screen at once, unit could be passed around, or same image displayed on many units
20	Facilitate mission briefing	N
21	Plan and Revise Route	Y
	(comments)	Has route planning SW with capabilities including: Display maps, terrain, route, bearing, distance to waypoints, contours of the ground, prominent features (e.g. roads,

		bodies of water)
22	Calculate distance between locations	Y
23	Consolidate multiple defensive positions	N
24	Create and display layout of defensive position and firing arcs	N
25	Logistics management	N
26	Weather effects analysis	N
27	Integrate GIS info with digital planning software	N
28	Processor	?
29	Memory	1MB built in memory
	Expansion?	N
30	Data Supported	NMEA 0183, RTCM 104 DGPS
	GPS level of accuracy	<15 meters
31	Range Finders	N
32	Barcode Scanners	N
Visualization Options (2D, 3D, video, etc)		
33	Reference photos	N
	(comments)	
34	Watch Video	N
	(comments)	
35	User selectable display of entities	?
36	Collaborative visualization of the operational area	N
37	Time appreciation	N
38	Visualize battlespace options and plans	N
39	Built-in Camera - Single shot	N
40	Built in Camera - Video	N
Field Operational Factors		
41	Camouflage	Y
	Night	N
42	Size	11.4cm x 5.8cm x 4.1cm
43	Weight	236 g
44	Stowage	Waterproof case
45	Power	3 AA
	Battery Life	15 hours
46	Ruggedness / Meets standards	?
	Waterproof	Y: IPX7
	Dirt/Sandproof	none
	Heat Resistant	?
	Cold Resistant	?
	Field Maintenance	Cleaning is possible, parts would just be a unit replacement
47	Means of Operator Input	Control keys
	Gloved hand operation	?
	Ports	RS232
48	Output	4-level greyscale LCD
	Screen size	5.1 cm diag
49	Security	N
50	Readable in all Lighting Conditions	Y

Garmin Colorado

Housekeeping Functions (internal device functionality, status, and security)		
1	Maintain awareness of sensor status and alarms	N
	(comments)	
2	Plan storage	N
3	Development Environment	
	Can additional programmable software be downloaded?	N
Mapping Functions (simple display of layers, location coordinates etc)		
4	Reference maps	N
	(comments)	Not able to load custom maps
5	Track own location	Y
6	Track location of blue forces	Y
	(comments)	Only geo-reference of other mobile GIS devices and geo-referenced messaging
7	Track location of enemy forces	N
	(comments)	
8	Track location of other entities	N
9	Navigate outdoors en route	Y
	(comments)	Heading, bearing, real-time GPS
10	Manage multiple routes	N
11	Navigate Indoors	N
	(comments)	
12	Navigate on Urban Streets	N
	(comments)	
Editing Functions (adding new features or textual input to the map - mark-up, pin-point, comments, etc)		
13	Manipulate maps	Y
14	Insert notes and/or hand drawn overlays on the digital map	N
	(comments)	
15	Insert notes and/or hand drawn overlays on photos	N
	(comments)	
16	Mark-up inaccurate maps	N
Data Processing and Analysis Functions (additional processes beyond basic mapping e.g. calculations, route planning automation)		
17	Automated Target Designation and Reporting	N
18	Distribute information to others	N
19	Ability for multiple people to share a common picture	Approx 2 people could view the screen at once, unit could be passed around, or same image displayed on many units
20	Facilitate mission briefing	N
21	Plan and Revise Route	Y
	(comments)	Has route planning SW with capabilities including: Display maps, terrain, route, bearing, distance to waypoints, contours of the ground, prominent features (e.g. roads, bodies of water)

22	Calculate distance between locations	Y
23	Consolidate multiple defensive positions	N
24	Create and display layout of defensive position and firing arcs	N
25	Logistics management	N
26	Weather effects analysis	N
27	Integrate GIS info with digital planning software	N
28	Processor	?
29	Memory	384MB built in
	Expansion?	N
30	Data Supported	NMEA 0183, RTCM 104 DGPS
	GPS level of accuracy	?
31	Range Finders	N
32	Barcode Scanners	N
Visualization Options (2D, 3D, video, etc)		
33	Reference photos	Y
	(comments)	No overlays
34	Watch Video	N
	(comments)	
35	User selectable display of entities	?
36	Collaborative visualization of the operational area	N
37	Time appreciation	N
38	Visualize battlespace options and plans	N
39	Built-in Camera - Single shot	N
40	Built in Camera - Video	N
Field Operational Factors		
41	Camouflage	Y
	Night	N
42	Size	13.9cm x 6.0cm x 3.5cm
43	Weight	207 g
44	Stowage	Waterproof case
45	Power	2 AA
	Battery Life	15 hours
46	Ruggedness / Meets standards	?
	Waterproof	Y: IPX8
	Dirt/Sandproof	none
	Heat Resistant	?
	Cold Resistant	?
	Field Maintenance	Cleaning is possible, parts would just be a unit replacement
47	Means of Operator Input	Control keys
	Gloved hand operation	?
	Ports	USB and NMEA 0183
48	Output	TFT colour
	Screen size	7.6 cm diag
49	Security	N
50	Readable in all Lighting Conditions	Y

General Dynamics Itronix Duo-Touch II

Housekeeping Functions (internal device functionality, status, and security)		
1	Maintain awareness of sensor status and alarms	SW
	(comments)	
2	Plan storage	SW
3	Development Environment	Windows XP Tablet PC editon 2005
	Can additional programmable software be downloaded?	Y
Mapping Functions (simple display of layers, location coordinates etc)		
4	Reference maps	Y
	(comments)	SW required for vegetation, DTED, and different formats
5	Track own location	SW
6	Track location of blue forces	SW
	(comments)	
7	Track location of enemy forces	SW
	(comments)	
8	Track location of other entities	SW
9	Navigate outdoors en route	SW
	(comments)	
10	Manage multiple routes	SW
11	Navigate Indoors	SW
	(comments)	
12	Navigate on Urban Streets	SW
	(comments)	
Editing Functions (adding new features or textual input to the map - mark-up, pin-point, comments, etc)		
13	Manipulate maps	Y
14	Insert notes and/or hand drawn overlays on the digital map	SW
	(comments)	
15	Insert notes and/or hand drawn overlays on photos	SW
	(comments)	
16	Mark-up inaccurate maps	SW
Data Processing and Analysis Functions (additional processes beyond basic mapping e.g. calculations, route planning automation)		
17	Automated Target Designation and Reporting	SW
18	Distribute information to others	SW
19	Ability for multiple people to share a common picture	Approx 4 people could view the screen at once, unit could be passed around, or same image displayed on many units
20	Facilitate mission briefing	SW
21	Plan and Revise Route	SW
	(comments)	
22	Calculate distance between locations	SW
23	Consolidate multiple defensive positions	SW
24	Create and display layout of defensive position and firing arcs	SW
25	Logistics management	SW

26	Weather effects analysis	SW
27	Integrate GIS info with digital planning software	SW
28	Processor	Intel Core 1.2 GHZ
29	Memory	2GB RAM, 120GB hard disk drive / 32 GB Solid State Hard Disk Drive
	Expansion?	Optional hard disk drives
30	Data Supported	?
	GPS level of accuracy	?
31	Range Finders	Possibly could be added in ports
32	Barcode Scanners	Could be added in ports
Visualization Options (2D, 3D, video, etc)		
33	Reference photos	Y
	(comments)	SW required for overlays
34	Watch Video	SW
	(comments)	
35	User selectable display of entities	SW
36	Collaborative visualization of the operational area	SW
37	Time appreciation	SW
38	Visualize battlespace options and plans	SW
39	Built-in Camera - Single shot	Could be added in ports
40	Built in Camera - Video	Could be added in ports
Field Operational Factors		
41	Camouflage	Y
	Night	N
42	Size	27cm x 18.4cm x 4.2cm
43	Weight	2 kg
44	Stowage	Carry case options with handle
45	Power	Li-Ion, requires charger
	Battery Life	?
46	Ruggedness / Meets standards	Y: MIL-STD-810F
	Waterproof	IP54
	Dirt/Sandproof	IP54
	Heat Resistant	60 C
	Cold Resistant	-20 C
	Field Maintenance	Cleaning is possible, parts would just be a unit replacement
47	Means of Operator Input	Touch screen, some control keys
	Gloved hand operation	Y
	Ports	PC slot for Type I or II card, Flash slot, RJ-11 and RJ45 jacks, 2 USB
48	Output	SVGA TFT
	Screen size	21.3 cm diag
49	Security	SW
50	Readable in all Lighting Conditions	Y

Hewlett Packard (HP) iPAQ 310 Travel Companion

Housekeeping Functions (internal device functionality, status, and security)		
1	Maintain awareness of sensor status and alarms	N
	(comments)	
2	Plan storage	N
3	Development Environment	Windows CE 5.0 with custom HP user interface
	Can additional programmable software be downloaded?	N
Mapping Functions (simple display of layers, location coordinates etc)		
4	Reference maps	N
	(comments)	Not able to load custom maps
5	Track own location	Y
6	Track location of blue forces	N
	(comments)	
7	Track location of enemy forces	N
	(comments)	
8	Track location of other entities	N
9	Navigate outdoors en route	Y
	(comments)	Heading, bearing, real-time GPS
10	Manage multiple routes	N
11	Navigate Indoors	N
	(comments)	
12	Navigate on Urban Streets	N
	(comments)	
Editing Functions (adding new features or textual input to the map - mark-up, pin-point, comments, etc)		
13	Manipulate maps	Y
14	Insert notes and/or hand drawn overlays on the digital map	N
	(comments)	
15	Insert notes and/or hand drawn overlays on photos	N
	(comments)	
16	Mark-up inaccurate maps	N
Data Processing and Analysis Functions (additional processes beyond basic mapping e.g. calculations, route planning automation)		
17	Automated Target Designation and Reporting	N
18	Distribute information to others	N
19	Ability for multiple people to share a common picture	Approx 2 people could view the screen at once, unit could be passed around, or same image displayed on many units
20	Facilitate mission briefing	N
21	Plan and Revise Route	Y
	(comments)	Has route planning SW with capabilities including: Display maps, terrain, route, bearing, distance to waypoints, contours of the ground, prominent features (e.g. roads, bodies of water)
22	Calculate distance between locations	Y

23	Consolidate multiple defensive positions	N
24	Create and display layout of defensive position and firing arcs	N
25	Logistics management	N
26	Weather effects analysis	N
27	Integrate GIS info with digital planning software	N
28	Processor	SiRF Titan 600 MHz ARM11
29	Memory	128MB SDRAM, 2GB Flash
	Expansion?	N
30	Data Supported	?
	GPS level of accuracy	?
31	Range Finders	N
32	Barcode Scanners	N
Visualization Options (2D, 3D, video, etc)		
33	Reference photos	N
	(comments)	
34	Watch Video	N
	(comments)	
35	User selectable display of entities	?
36	Collaborative visualization of the operational area	N
37	Time appreciation	N
38	Visualize battlespace options and plans	N
39	Built-in Camera - Single shot	N
40	Built in Camera - Video	N
Field Operational Factors		
41	Camouflage	Y
	Night	N
42	Size	11cm x 8.7cm x 1.8cm
43	Weight	187 g
44	Stowage	?
45	Power	Li-Ion, requires charger
	Battery Life	?
46	Ruggedness / Meets standards	N
	Waterproof	N
	Dirt/Sandproof	none
	Heat Resistant	?
	Cold Resistant	?
	Field Maintenance	Cleaning is possible, parts would just be a unit replacement
47	Means of Operator Input	Touch screen
	Gloved hand operation	Y
	Ports	none
48	Output	TFT 16-bit RGB, WVGA
	Screen size	10.9 cm diag
49	Security	N
50	Readable in all Lighting Conditions	Y

Intermec CN3

Housekeeping Functions (internal device functionality, status, and security)		
1	Maintain awareness of sensor status and alarms	SW
	(comments)	
2	Plan storage	SW
3	Development Environment	Windows Mobile 5.0, 6.1
	Can additional programmable software be downloaded?	Y
Mapping Functions (simple display of layers, location coordinates etc)		
4	Reference maps	Y
	(comments)	SW required for vegetation, DTED, and different formats
5	Track own location	SW
6	Track location of blue forces	SW
	(comments)	
7	Track location of enemy forces	SW
	(comments)	
8	Track location of other entities	SW
9	Navigate outdoors en route	SW
	(comments)	
10	Manage multiple routes	SW
11	Navigate Indoors	SW
	(comments)	
12	Navigate on Urban Streets	SW
	(comments)	
Editing Functions (adding new features or textual input to the map - mark-up, pin-point, comments, etc)		
13	Manipulate maps	Y
14	Insert notes and/or hand drawn overlays on the digital map	SW
	(comments)	
15	Insert notes and/or hand drawn overlays on photos	SW
	(comments)	
16	Mark-up inaccurate maps	SW
Data Processing and Analysis Functions (additional processes beyond basic mapping e.g. calculations, route planning automation)		
17	Automated Target Designation and Reporting	SW
18	Distribute information to others	SW
19	Ability for multiple people to share a common picture	Approx 2 people could view the screen at once, unit could be passed around, or same image displayed on many units
20	Facilitate mission briefing	SW
21	Plan and Revise Route	SW
	(comments)	
22	Calculate distance between locations	SW
23	Consolidate multiple defensive positions	SW
24	Create and display layout of defensive position and firing arcs	SW
25	Logistics management	SW

26	Weather effects analysis	SW
27	Integrate GIS info with digital planning software	SW
28	Processor	Intel PXA270 @ 520MHz
29	Memory	120 MB RAM, 256 Flash with slot for memory cards up to 2GB
	Expansion?	miniSD slot for memory
30	Data Supported	?
	GPS level of accuracy	?
31	Range Finders	N
32	Barcode Scanners	Y - 1MP area imager
Visualization Options (2D, 3D, video, etc)		
33	Reference photos	Y
	(comments)	SW required for overlays
34	Watch Video	SW
	(comments)	
35	User selectable display of entities	SW
36	Collaborative visualization of the operational area	SW
37	Time appreciation	SW
38	Visualize battlespace options and plans	SW
39	Built-in Camera - Single shot	Y - 3MP colour camera
40	Built in Camera - Video	N
Field Operational Factors		
41	Camouflage	Likely an option
	Night	N
42	Size	16.5cm x 8.1cm x 3.3cm
43	Weight	454 g
44	Stowage	?
45	Power	Li-Ion, requires charger
	Battery Life	
46	Ruggedness / Meets standards	Y: MIL-STD 810G
	Waterproof	somewhat: IP54
	Dirt/Sandproof	somewhat: IP54
	Heat Resistant	50 C
	Cold Resistant	-10 C
	Field Maintenance	Cleaning is possible, parts would just be a unit replacement
47	Means of Operator Input	Touch screen, some control keys
	Gloved hand operation	Y
	Ports	none
48	Output	240x320 pixel, QVGA, 64K TFT
	Screen size	8.9 cm (diagonal)
49	Security	SW
50	Readable in all Lighting Conditions	?

Leica Geosystems DX10

Housekeeping Functions (internal device functionality, status, and security)		
1	Maintain awareness of sensor status and alarms	SW
	(comments)	
2	Plan storage	SW
3	Development Environment	Windows CE 5.0
	Can additional programmable software be downloaded?	Y
Mapping Functions (simple display of layers, location coordinates etc)		
4	Reference maps	Y
	(comments)	SW required for vegetation, DTED, and different formats
5	Track own location	SW
6	Track location of blue forces	SW
	(comments)	
7	Track location of enemy forces	SW
	(comments)	
8	Track location of other entities	SW
9	Navigate outdoors en route	SW
	(comments)	
10	Manage multiple routes	SW
11	Navigate Indoors	SW
	(comments)	
12	Navigate on Urban Streets	SW
	(comments)	
Editing Functions (adding new features or textual input to the map - mark-up, pin-point, comments, etc)		
13	Manipulate maps	Y
14	Insert notes and/or hand drawn overlays on the digital map	SW
	(comments)	
15	Insert notes and/or hand drawn overlays on photos	SW
	(comments)	
16	Mark-up inaccurate maps	SW
Data Processing and Analysis Functions (additional processes beyond basic mapping e.g. calculations, route planning automation)		
17	Automated Target Designation and Reporting	SW
18	Distribute information to others	SW
19	Ability for multiple people to share a common picture	Approx 2 people could view the screen at once, unit could be passed around, or same image displayed on many units
20	Facilitate mission briefing	SW
21	Plan and Revise Route	SW
	(comments)	
22	Calculate distance between locations	SW
23	Consolidate multiple defensive positions	SW
24	Create and display layout of defensive position and firing arcs	SW
25	Logistics management	SW
26	Weather effects	SW

	analysis	
27	Integrate GIS info with digital planning software	SW
28	Processor	Intel PXA270 @ 520MHz
29	Memory	128 MB RAM, 256 MB flash
	Expansion?	Type I or Type II compact flash slots
30	Data Supported	?
	GPS level of accuracy	?
31	Range Finders	Possibly could be added in ports
32	Barcode Scanners	Could be added in ports
Visualization Options (2D, 3D, video, etc)		
33	Reference photos	Y
	(comments)	SW required for overlays
34	Watch Video	SW
	(comments)	
35	User selectable display of entities	SW
36	Collaborative visualization of the operational area	SW
37	Time appreciation	SW
38	Visualize battlespace options and plans	SW
39	Built-in Camera - Single shot	Could be added in ports
40	Built in Camera - Video	Could be added in ports
Field Operational Factors		
41	Camouflage	Y
	Night	N
42	Size	16.5cm x 8.9cm x 4.3cm
43	Weight	482 g
44	Stowage	?
45	Power	Li-Ion, requires charger
	Battery Life	20 hours on 1 charge
46	Ruggedness / Meets standards	Y: MIL-STD 810F
	Waterproof	Y: IP67
	Dirt/Sandproof	Y:IP67
	Heat Resistant	60 C
	Cold Resistant	-30 C
	Field Maintenance	Cleaning is possible, parts would just be a unit replacement
47	Means of Operator Input	Touch screen, some control keys
	Gloved hand operation	Y
	Ports	SDIO for peripherals
48	Output	240x320 pixel, 1/4 VGA, TFT
	Screen size	8.9 cm (diagonal)
49	Security	SW
50	Readable in all Lighting Conditions	Y

Motorola - Symbol Technologies MC70

Housekeeping Functions (internal device functionality, status, and security)		
1	Maintain awareness of sensor status and alarms	SW
	(comments)	
2	Plan storage	SW
3	Development Environment	Windows Mobile 5.0
	Can additional programmable software be downloaded?	Y
Mapping Functions (simple display of layers, location coordinates etc)		
4	Reference maps	Y
	(comments)	SW required for vegetation, DTED, and different formats
5	Track own location	SW
6	Track location of blue forces	SW
	(comments)	
7	Track location of enemy forces	SW
	(comments)	
8	Track location of other entities	SW
9	Navigate outdoors en route	SW
	(comments)	
10	Manage multiple routes	SW
11	Navigate Indoors	SW
	(comments)	
12	Navigate on Urban Streets	SW
	(comments)	
Editing Functions (adding new features or textual input to the map - mark-up, pin-point, comments, etc)		
13	Manipulate maps	Y
14	Insert notes and/or hand drawn overlays on the digital map	SW
	(comments)	
15	Insert notes and/or hand drawn overlays on photos	SW
	(comments)	
16	Mark-up inaccurate maps	SW
Data Processing and Analysis Functions (additional processes beyond basic mapping e.g. calculations, route planning automation)		
17	Automated Target Designation and Reporting	SW
18	Distribute information to others	SW
19	Ability for multiple people to share a common picture	Approx 2 people could view the screen at once, unit could be passed around, or same image displayed on many units
20	Facilitate mission briefing	SW
21	Plan and Revise Route	SW
	(comments)	
22	Calculate distance between locations	SW
23	Consolidate multiple defensive positions	SW
24	Create and display layout of defensive position and firing arcs	SW

25	Logistics management	SW
26	Weather effects analysis	SW
27	Integrate GIS info with digital planning software	SW
28	Processor	Intel Xscale PXA270 @ 624 MHz
29	Memory	128 MB RAM, 128 MB ROM
	Expansion?	SDIO
30	Data Supported	?
	GPS level of accuracy	?
31	Range Finders	Possibly could be added in ports
32	Barcode Scanners	Y - attachment
Visualization Options (2D, 3D, video, etc)		
33	Reference photos	Y
	(comments)	SW required for overlays
34	Watch Video	SW
	(comments)	
35	User selectable display of entities	SW
36	Collaborative visualization of the operational area	SW
37	Time appreciation	SW
38	Visualize battlespace options and plans	SW
39	Built-in Camera - Single shot	Could be added in ports
40	Built in Camera - Video	Could be added in ports
Field Operational Factors		
41	Camouflage	Y
	Night	N
42	Size	15.3cm x 7.6cm x 3.7cm
43	Weight	400 g
44	Stowage	?
45	Power	Li-Ion, requires charger
	Battery Life	?
46	Ruggedness / Meets standards	No standard. "4ft drop to concrete, 6 drops per 6 sides"
	Waterproof	somewhat: IP54
	Dirt/Sandproof	somewhat: IP54
	Heat Resistant	50 C
	Cold Resistant	-10 C
	Field Maintenance	Cleaning is possible, parts would just be a unit replacement
47	Means of Operator Input	Touch screen, full alphanumeric keypad
	Gloved hand operation	Y
	Ports	USB, RS232
48	Output	240x320 pixel, QVGA, 64K TFT
	Screen size	8.9 cm (diagonal)
49	Security	SW
50	Readable in all Lighting Conditions	Y

Psion Teklogix Workabout PRO

Housekeeping Functions (internal device functionality, status, and security)		
1	Maintain awareness of sensor status and alarms	SW
	(comments)	
2	Plan storage	SW
3	Development Environment	Windows CE 5.0, Windows Mobile 6
	Can additional programmable software be downloaded?	Y
Mapping Functions (simple display of layers, location coordinates etc)		
4	Reference maps	Y
	(comments)	SW required for vegetation, DTED, and different formats
5	Track own location	SW
6	Track location of blue forces	SW
	(comments)	
7	Track location of enemy forces	SW
	(comments)	
8	Track location of other entities	SW
9	Navigate outdoors en route	SW
	(comments)	
10	Manage multiple routes	SW
11	Navigate Indoors	SW
	(comments)	
12	Navigate on Urban Streets	SW
	(comments)	
Editing Functions (adding new features or textual input to the map - mark-up, pin-point, comments, etc)		
13	Manipulate maps	Y
14	Insert notes and/or hand drawn overlays on the digital map	SW
	(comments)	
15	Insert notes and/or hand drawn overlays on photos	SW
	(comments)	
16	Mark-up inaccurate maps	SW
Data Processing and Analysis Functions (additional processes beyond basic mapping e.g. calculations, route planning automation)		
17	Automated Target Designation and Reporting	SW
18	Distribute information to others	SW
19	Ability for multiple people to share a common picture	Approx 2 people could view the screen at once, unit could be passed around, or same image displayed on many units
20	Facilitate mission briefing	SW
21	Plan and Revise Route	SW
	(comments)	
22	Calculate distance between locations	SW
23	Consolidate multiple defensive positions	SW
24	Create and display layout of defensive position and firing arcs	SW

25	Logistics management	SW
26	Weather effects analysis	SW
27	Integrate GIS info with digital planning software	SW
28	Processor	PXA270 @ 520MHz
29	Memory	128 MB RAM, 256 MB Flash
	Expansion?	Type II CF Card Slot, 100-PIN expansion interface, SD/MMC memory card slot
30	Data Supported	?
	GPS level of accuracy	?
31	Range Finders	Possibly could be added in ports
32	Barcode Scanners	Y - attachment
Visualization Options (2D, 3D, video, etc)		
33	Reference photos	Y
	(comments)	SW required for overlays
34	Watch Video	SW
	(comments)	
35	User selectable display of entities	SW
36	Collaborative visualization of the operational area	SW
37	Time appreciation	SW
38	Visualize battlespace options and plans	SW
39	Built-in Camera - Single shot	Could be added in ports
40	Built in Camera - Video	Could be added in ports
Field Operational Factors		
41	Camouflage	Y
	Night	N
42	Size	20.0cm x 10.0cm x 4.2cm
43	Weight	455 g
44	Stowage	?
45	Power	Rechargable 3.7V, comes with charger
	Battery Life	
46	Ruggedness / Meets standards	No standard. "Withstands multiple drops from 6 ft to concrete"
	Waterproof	Y: IP65
	Dirt/Sandproof	Y: IP65
	Heat Resistant	50 C
	Cold Resistant	-20 C
	Field Maintenance	Cleaning is possible, parts would just be a unit replacement
47	Means of Operator Input	Touch screen, buttons for numbers, navigation, alpha is an option
	Gloved hand operation	Y
	Ports	RS232, USB interface
48	Output	480x640 pixel, full VGA, TFT adjustable backlight
	Screen size	9.1cm (diagonal)
49	Security	SW
50	Readable in all Lighting Conditions	Y

Trimble Geoexplorer GeoXT

Housekeeping Functions (internal device functionality, status, and security)		
1	Maintain awareness of sensor status and alarms	SW
	(comments)	
2	Plan storage	SW
3	Development Environment	Windows Mobile 6.0
	Can additional programmable software be downloaded?	Y
Mapping Functions (simple display of layers, location coordinates etc)		
4	Reference maps	Y
	(comments)	SW required for vegetation, DTED, and different formats
5	Track own location	Y
6	Track location of blue forces	SW
	(comments)	
7	Track location of enemy forces	SW
	(comments)	
8	Track location of other entities	SW
9	Navigate outdoors en route	Y
	(comments)	Heading, bearing, real-time GPS. SA and route updating would be dependant on SW
10	Manage multiple routes	SW
11	Navigate Indoors	SW
	(comments)	
12	Navigate on Urban Streets	SW
	(comments)	
Editing Functions (adding new features or textual input to the map - mark-up, pin-point, comments, etc)		
13	Manipulate maps	Y
14	Insert notes and/or hand drawn overlays on the digital map	SW
	(comments)	
15	Insert notes and/or hand drawn overlays on photos	SW
	(comments)	
16	Mark-up inaccurate maps	SW
Data Processing and Analysis Functions (additional processes beyond basic mapping e.g. calculations, route planning automation)		
17	Automated Target Designation and Reporting	SW
18	Distribute information to others	SW
19	Ability for multiple people to share a common picture	Approx 2 people could view the screen at once, unit could be passed around, or same image displayed on many units
20	Facilitate mission briefing	SW
21	Plan and Revise Route	SW
	(comments)	
22	Calculate distance between locations	Y
23	Consolidate multiple defensive positions	SW
24	Create and display layout of defensive position and firing arcs	SW

25	Logistics management	SW
26	Weather effects analysis	SW
27	Integrate GIS info with digital planning software	SW
28	Processor	Marvell PXA270 Xscale CPU @ 520 MHz
29	Memory	128 MB RAM, 1GB Flash
	Expansion?	SD card slot
30	Data Supported	?
	GPS level of accuracy	Less than 1m
31	Range Finders	Possibly could be added in ports
32	Barcode Scanners	Could be added in ports
Visualization Options (2D, 3D, video, etc)		
33	Reference photos	Y
	(comments)	SW required for overlays
34	Watch Video	SW
	(comments)	
35	User selectable display of entities	SW
36	Collaborative visualization of the operational area	SW
37	Time appreciation	SW
38	Visualize battlespace options and plans	SW
39	Built-in Camera - Single shot	Could be added in ports
40	Built in Camera - Video	Could be added in ports
Field Operational Factors		
41	Camouflage	Likely an option
	Night	N
42	Size	21.5cm x 9.9cm x 7.7cm
43	Weight	800 g
44	Stowage	?
45	Power	Internal, rechargable
	Battery Life	~10h depending on use
46	Ruggedness / Meets standards	Y: meets MIL-STD-810F
	Waterproof	Y: IP65
	Dirt/Sandproof	Y: IP65
	Heat Resistant	60 C
	Cold Resistant	-20 C
	Field Maintenance	Cleaning is possible, parts would just be a unit replacement
47	Means of Operator Input	Touch screen, some control keys
	Gloved hand operation	Y
	Ports	USB, RS-232
48	Output	480 x 640 pixel, VGA TFT, 16bit colour, LED back light
	Screen size	8.9 cm (diagonal)
49	Security	SW
50	Readable in all Lighting Conditions	Y

Trimble Recon GPS XC

Housekeeping Functions (internal device functionality, status, and security)		
1	Maintain awareness of sensor status and alarms	SW
	(comments)	
2	Plan storage	SW
3	Development Environment	Windows Mobile 6.1
	Can additional programmable software be downloaded?	Y
Mapping Functions (simple display of layers, location coordinates etc)		
4	Reference maps	Y
	(comments)	SW required for vegetation, DTED, and different formats
5	Track own location	Y
6	Track location of blue forces	SW
	(comments)	
7	Track location of enemy forces	SW
	(comments)	
8	Track location of other entities	SW
9	Navigate outdoors en route	Y
	(comments)	Heading, bearing, real-time GPS. SA and route updating would be dependant on SW
10	Manage multiple routes	SW
11	Navigate Indoors	SW
	(comments)	
12	Navigate on Urban Streets	SW
	(comments)	
Editing Functions (adding new features or textual input to the map - mark-up, pin-point, comments, etc)		
13	Manipulate maps	Y
14	Insert notes and/or hand drawn overlays on the digital map	SW
	(comments)	
15	Insert notes and/or hand drawn overlays on photos	SW
	(comments)	
16	Mark-up inaccurate maps	SW
Data Processing and Analysis Functions (additional processes beyond basic mapping e.g. calculations, route planning automation)		
17	Automated Target Designation and Reporting	SW
18	Distribute information to others	SW
19	Ability for multiple people to share a common picture	Approx 2 people could view the screen at once, unit could be passed around, or same image displayed on many units
20	Facilitate mission briefing	SW
21	Plan and Revise Route	SW
	(comments)	
22	Calculate distance between locations	Y
23	Consolidate multiple defensive positions	SW
24	Create and display layout of defensive	SW

	position and firing arcs	
25	Logistics management	SW
26	Weather effects analysis	SW
27	Integrate GIS info with digital planning software	SW
28	Processor	Intel PXA255 Xscale CPU @ 400 MHz
29	Memory	? RAM, 256 MB Flash
	Expansion?	1 type I slot, 1 type II slot
30	Data Supported	?
	GPS level of accuracy	2 to 5m
31	Range Finders	Possibly could be added in ports
32	Barcode Scanners	Could be added in ports
Visualization Options (2D, 3D, video, etc)		
33	Reference photos	Y
	(comments)	SW required for overlays
34	Watch Video	SW
	(comments)	
35	User selectable display of entities	SW
36	Collaborative visualization of the operational area	SW
37	Time appreciation	SW
38	Visualize battlespace options and plans	SW
39	Built-in Camera - Single shot	Could be added in ports
40	Built in Camera - Video	Could be added in ports
Field Operational Factors		
41	Camouflage	Likely an option
	Night	N
42	Size	22.5cm x 9.5cm x 4.5cm
43	Weight	560 g
44	Stowage	?
45	Power	Internal, rechargable
	Battery Life	?
46	Ruggedness / Meets standards	Y: meets MIL-STD-810F
	Waterproof	Y: IP67
	Dirt/Sandproof	Y: IP67
	Heat Resistant	50 C
	Cold Resistant	-10 C
	Field Maintenance	Cleaning is possible, parts would just be a unit replacement
47	Means of Operator Input	Touch screen, some control keys
	Gloved hand operation	Y
	Ports	RS-232, USB
48	Output	240 x 320 pixel, 1/4 VGA, colour, TFT with LED front light
	Screen size	? ~10cm diag
49	Security	SW
50	Readable in all Lighting Conditions	Y

Tripod Data Systems (TDS) Recon

Housekeeping Functions (internal device functionality, status, and security)		
1	Maintain awareness of sensor status and alarms	SW
	(comments)	
2	Plan storage	SW
3	Development Environment	Windows Mobile 6
	Can additional programmable software be downloaded?	Y
Mapping Functions (simple display of layers, location coordinates etc)		
4	Reference maps	Y
	(comments)	SW required for vegetation, DTED, and different formats
5	Track own location	Y
6	Track location of blue forces	SW
	(comments)	
7	Track location of enemy forces	SW
	(comments)	
8	Track location of other entities	SW
9	Navigate outdoors en route	Y
	(comments)	Heading, bearing, real-time GPS. SA and route updating would be dependant on SW
10	Manage multiple routes	SW
11	Navigate Indoors	SW
	(comments)	
12	Navigate on Urban Streets	SW
	(comments)	
Editing Functions (adding new features or textual input to the map - mark-up, pin-point, comments, etc)		
13	Manipulate maps	Y
14	Insert notes and/or hand drawn overlays on the digital map	SW
	(comments)	
15	Insert notes and/or hand drawn overlays on photos	SW
	(comments)	
16	Mark-up inaccurate maps	SW
Data Processing and Analysis Functions (additional processes beyond basic mapping e.g. calculations, route planning automation)		
17	Automated Target Designation and Reporting	SW
18	Distribute information to others	SW
19	Ability for multiple people to share a common picture	Approx 2 people could view the screen at once, unit could be passed around, or same image displayed on many units
20	Facilitate mission briefing	SW
21	Plan and Revise Route	SW
	(comments)	
22	Calculate distance between locations	Y
23	Consolidate multiple defensive positions	SW
24	Create and display layout of defensive	SW

	position and firing arcs	
25	Logistics management	SW
26	Weather effects analysis	SW
27	Integrate GIS info with digital planning software	SW
28	Processor	Intel PXA255 Xscale CPU @ 400 MHz
29	Memory	64 MB high speed SDRAM ~6MB reserved, 256 MB nonvolitile flash storage
	Expansion?	1x Type I and 1x Type II Compact Flash slots
30	Data Supported	?
	GPS level of accuracy	?
31	Range Finders	Possibly could be added in ports
32	Barcode Scanners	Could be added in ports
Visualization Options (2D, 3D, video, etc)		
33	Reference photos	Y
	(comments)	SW required for overlays
34	Watch Video	SW
	(comments)	
35	User selectable display of entities	SW
36	Collaborative visualization of the operational area	SW
37	Time appreciation	SW
38	Visualize battlespace options and plans	SW
39	Built-in Camera - Single shot	Could be added in ports
40	Built in Camera - Video	Could be added in ports
Field Operational Factors		
41	Camouflage	Likely an option
	Night	Y
42	Size	16.5cm x 9.5 cm x 4.5 cm
43	Weight	490 g
44	Stowage	Tactical pouches available
45	Power	AA - field replaceable
	Battery Life	15 hours
46	Ruggedness / Meets standards	Y: meets MIL-STD-810F
	Waterproof	Y: MIL-STD 810F, IP67
	Dirt/Sandproof	Y: MIL-STD 810F, IP67
	Heat Resistant	60 C
	Cold Resistant	-30 C
	Field Maintenance	Cleaning is possible, parts would just be a unit replacement
47	Means of Operator Input	Touch screen, buttons for numbers and navigation
	Gloved hand operation	Y
	Ports	9-pin male D-shell RS232 serial and USB
48	Output	240 x 320 pixel, 1/4 VGA, colour, TFT with LED front light
	Screen size	? ~10cm diag
49	Security	SW
50	Readable in all Lighting Conditions	Y

Tripod Data Systems (TDS) Nomad

Housekeeping Functions (internal device functionality, status, and security)		
1	Maintain awareness of sensor status and alarms	SW
	(comments)	
2	Plan storage	SW
3	Development Environment	Windows Mobile 7
	Can additional programmable software be downloaded?	Y
Mapping Functions (simple display of layers, location coordinates etc)		
4	Reference maps	Y
	(comments)	SW required for vegetation, DTED, and different formats
5	Track own location	Y
6	Track location of blue forces	SW
	(comments)	
7	Track location of enemy forces	SW
	(comments)	
8	Track location of other entities	SW
9	Navigate outdoors en route	Y
	(comments)	Heading, bearing, real-time GPS. SA and route updating would be dependant on SW
10	Manage multiple routes	SW
11	Navigate Indoors	SW
	(comments)	
12	Navigate on Urban Streets	SW
	(comments)	
Editing Functions (adding new features or textual input to the map - mark-up, pin-point, comments, etc)		
13	Manipulate maps	Y
14	Insert notes and/or hand drawn overlays on the digital map	SW
	(comments)	
15	Insert notes and/or hand drawn overlays on photos	SW
	(comments)	
16	Mark-up inaccurate maps	SW
Data Processing and Analysis Functions (additional processes beyond basic mapping e.g. calculations, route planning automation)		
17	Automated Target Designation and Reporting	SW
18	Distribute information to others	SW
19	Ability for multiple people to share a common picture	Approx 2 people could view the screen at once, unit could be passed around, or same image displayed on many units
20	Facilitate mission briefing	SW
21	Plan and Revise Route	SW
	(comments)	
22	Calculate distance between locations	Y
23	Consolidate multiple defensive positions	SW
24	Create and display layout of defensive	SW

	position and firing arcs	
25	Logistics management	SW
26	Weather effects analysis	SW
27	Integrate GIS info with digital planning software	SW
28	Processor	Marvell PXA320 Xscale CPU @ 806 MHz
29	Memory	128 MB DDR SDRAM ~30MB reserved, 2 GB nonvolitile flash storage
	Expansion?	1x Type I and 1x Type II Compact Flash slots
30	Data Supported	?
	GPS level of accuracy	?
31	Range Finders	Possibly could be added in ports
32	Barcode Scanners	Could be added in ports
Visualization Options (2D, 3D, video, etc)		
33	Reference photos	Y
	(comments)	SW required for overlays
34	Watch Video	SW
	(comments)	
35	User selectable display of entities	SW
36	Collaborative visualization of the operational area	SW
37	Time appreciation	SW
38	Visualize battlespace options and plans	SW
39	Built-in Camera - Single shot	Could be added in ports
40	Built in Camera - Video	Could be added in ports
Field Operational Factors		
41	Camouflage	Likely an option
	Night	Y
42	Size	17.6cm x 10cm x 5cm
43	Weight	596 g
44	Stowage	Tactical pouches available
45	Power	AA - field replaceable
	Battery Life	15 hours
46	Ruggedness / Meets standards	Y: meets MIL-STD-810F
	Waterproof	Y: MIL-STD 810F, IP67
	Dirt/Sandproof	Y: MIL-STD 810F, IP67
	Heat Resistant	60 C
	Cold Resistant	-30 C
	Field Maintenance	Cleaning is possible, parts would just be a unit replacement
47	Means of Operator Input	Touch screen, buttons for numbers and navigation
	Gloved hand operation	Y
	Ports	9-pin male D-shell RS232 serial and USB
48	Output	480 x 640 pixel, Full VGA, colour, TFT with LED front light
	Screen size	? ~10cm diag
49	Security	SW
50	Readable in all Lighting Conditions	Y

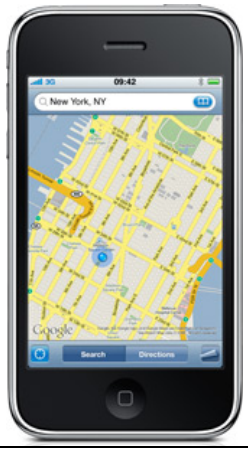
Xplore iX104

Housekeeping Functions (internal device functionality, status, and security)		
1	Maintain awareness of sensor status and alarms	SW
	(comments)	
2	Plan storage	SW
3	Development Environment	Windows XP Tablet PC editon or Vista Business
	Can additional programmable software be downloaded?	Y
Mapping Functions (simple display of layers, location coordinates etc)		
4	Reference maps	Y
	(comments)	SW required for vegetation, DTED, and different formats
5	Track own location	SW
6	Track location of blue forces	SW
	(comments)	
7	Track location of enemy forces	SW
	(comments)	
8	Track location of other entities	SW
9	Navigate outdoors en route	SW
	(comments)	
10	Manage multiple routes	SW
11	Navigate Indoors	SW
	(comments)	
12	Navigate on Urban Streets	SW
	(comments)	
Editing Functions (adding new features or textual input to the map - mark-up, pin-point, comments, etc)		
13	Manipulate maps	Y
14	Insert notes and/or hand drawn overlays on the digital map	SW
	(comments)	
15	Insert notes and/or hand drawn overlays on photos	SW
	(comments)	
16	Mark-up inaccurate maps	SW
Data Processing and Analysis Functions (additional processes beyond basic mapping e.g. calculations, route planning automation)		
17	Automated Target Designation and Reporting	SW
18	Distribute information to others	SW
19	Ability for multiple people to share a common picture	Approx 4 people could view the screen at once, unit could be passed around, or same image displayed on many units
20	Facilitate mission briefing	SW
21	Plan and Revise Route	SW
	(comments)	
22	Calculate distance between locations	SW
23	Consolidate multiple defensive positions	SW
24	Create and display layout of defensive position and firing arcs	SW
25	Logistics management	SW

26	Weather effects analysis	SW
27	Integrate GIS info with digital planning software	SW
28	Processor	Intel 2500 Core Duo @ 1.2GHz
29	Memory	1 or 2GB RAM, 8MB ROM, 120GB Hard drive
	Expansion?	Optional hard disk drives
30	Data Supported	?
	GPS level of accuracy	?
31	Range Finders	Possibly could be added in ports
32	Barcode Scanners	Could be added in ports
Visualization Options (2D, 3D, video, etc)		
33	Reference photos	Y
	(comments)	SW required for overlays
34	Watch Video	SW
	(comments)	
35	User selectable display of entities	SW
36	Collaborative visualization of the operational area	SW
37	Time appreciation	SW
38	Visualize battlespace options and plans	SW
39	Built-in Camera - Single shot	Could be added in ports
40	Built in Camera - Video	Could be added in ports
Field Operational Factors		
41	Camouflage	Y
	Night	N
42	Size	28.4cm x 21.0cm x 4.1 cm
43	Weight	2.23 Kg
44	Stowage	?
45	Power	Li-Ion, requires charger
	Battery Life	4.5 hours
46	Ruggedness / Meets standards	Y: meets MIL-STD-810F
	Waterproof	Y: MIL-STD 810F, IP65
	Dirt/Sandproof	Y: MIL-STD 810F, IP65
	Heat Resistant	60 C
	Cold Resistant	-40 C
	Field Maintenance	Cleaning is possible, parts would just be a unit replacement
47	Means of Operator Input	Touch screen, some control keys
	Gloved hand operation	Y
	Ports	USB, RJ-34, RS232/422/485, VGA
48	Output	XGA TFT 16M colours
	Screen size	26.4cm (diag)
49	Security	SW
50	Readable in all Lighting Conditions	Y

Cell/Smart Phones

Apple iPhone



Housekeeping Functions (internal device functionality, status, and security)		
1	Maintain awareness of sensor status and alarms	SW
	(comments)	
2	Plan storage	SW
3	Development Environment	iPhone OS
	Can additional programmable software be downloaded?	Y
Mapping Functions (simple display of layers, location coordinates etc)		
4	Reference maps	Y
	(comments)	SW required for vegetation, DTED, and different formats
5	Track own location	Y
6	Track location of blue forces	SW
	(comments)	
7	Track location of enemy forces	SW
	(comments)	
8	Track location of other entities	SW
9	Navigate outdoors en route	SW
	(comments)	
10	Manage multiple routes	SW
11	Navigate Indoors	SW
	(comments)	
12	Navigate on Urban Streets	SW
	(comments)	
Editing Functions (adding new features or textual input to the map - mark-up, pin-point, comments, etc)		
13	Manipulate maps	Y
14	Insert notes and/or hand drawn overlays on the digital map	SW
	(comments)	
15	Insert notes and/or hand drawn overlays on photos	SW
	(comments)	
16	Mark-up inaccurate maps	SW
Data Processing and Analysis Functions (additional processes beyond basic mapping e.g. calculations, route planning automation)		
17	Automated Target Designation and Reporting	SW
18	Distribute information to others	SW
19	Ability for multiple people to share a common picture	Approx 2 people could view the screen at once, unit could be passed around, or same image displayed on many units
20	Facilitate mission briefing	SW
21	Plan and Revise Route	SW
	(comments)	
22	Calculate distance between locations	SW
23	Consolidate multiple defensive positions	SW
24	Create and display layout of defensive position and firing arcs	SW

25	Logistics management	SW
26	Weather effects analysis	SW
27	Integrate GIS info with digital planning software	SW
28	Processor	?
29	Memory	16G or 32G Flash
	Expansion?	?
30	Data Supported	?
	GPS level of accuracy	?
31	Range Finders	N
32	Barcode Scanners	N
Visualization Options (2D, 3D, video, etc)		
33	Reference photos	Y
	(comments)	SW required for overlays
34	Watch Video	SW
	(comments)	
35	User selectable display of entities	SW
36	Collaborative visualization of the operational area	SW
37	Time appreciation	SW
38	Visualize battlespace options and plans	SW
39	Built-in Camera - Single shot	Y
40	Built in Camera - Video	Y
Field Operational Factors		
41	Camouflage	Likely an option
	Night	N
42	Size	11.5cm x 6.2cm x 1.2cm
43	Weight	135g
44	Stowage	many case options
45	Power	Li-Ion internal, charger
	Battery Life	5hours talk time, 5 hours internet
46	Ruggedness / Meets standards	no standards
	Waterproof	N
	Dirt/Sandproof	N
	Heat Resistant	35C
	Cold Resistant	0C
	Field Maintenance	Cleaning is possible, parts would just be a unit replacement
47	Means of Operator Input	Touch screen, some control keys
	Gloved hand operation	SW
	Ports	USB
48	Output	163ppi colour
	Screen size	8.9cm diag
49	Security	Password
50	Readable in all Lighting Conditions	?

Blackberry Smartphone

Housekeeping Functions (internal device functionality, status, and security)		
1	Maintain awareness of sensor status and alarms	SW
	(comments)	
2	Plan storage	SW
3	Development Environment	Blackberry OS
	Can additional programmable software be downloaded?	Y
Mapping Functions (simple display of layers, location coordinates etc)		
4	Reference maps	Y
	(comments)	SW required for vegetation, DTED, and different formats
5	Track own location	Y
6	Track location of blue forces	SW
	(comments)	
7	Track location of enemy forces	SW
	(comments)	
8	Track location of other entities	SW
9	Navigate outdoors en route	SW
	(comments)	
10	Manage multiple routes	SW
11	Navigate Indoors	SW
	(comments)	
12	Navigate on Urban Streets	SW
	(comments)	
Editing Functions (adding new features or textual input to the map - mark-up, pin-point, comments, etc)		
13	Manipulate maps	Y
14	Insert notes and/or hand drawn overlays on the digital map	SW
	(comments)	
15	Insert notes and/or hand drawn overlays on photos	SW
	(comments)	
16	Mark-up inaccurate maps	SW
Data Processing and Analysis Functions (additional processes beyond basic mapping e.g. calculations, route planning automation)		
17	Automated Target Designation and Reporting	SW
18	Distribute information to others	SW
19	Ability for multiple people to share a common picture	Approx 2 people could view the screen at once, unit could be passed around, or same image displayed on many units
20	Facilitate mission briefing	SW
21	Plan and Revise Route	SW
	(comments)	
22	Calculate distance between locations	SW
23	Consolidate multiple defensive positions	SW
24	Create and display layout of defensive position and firing arcs	SW

25	Logistics management	SW
26	Weather effects analysis	SW
27	Integrate GIS info with digital planning software	SW
28	Processor	?
29	Memory	256MB "Built-in Memory"
	Expansion?	"Expandable"
30	Data Supported	?
	GPS level of accuracy	?
31	Range Finders	N
32	Barcode Scanners	N
Visualization Options (2D, 3D, video, etc)		
33	Reference photos	Y
	(comments)	SW required for overlays
34	Watch Video	SW
	(comments)	
35	User selectable display of entities	SW
36	Collaborative visualization of the operational area	SW
37	Time appreciation	SW
38	Visualize battlespace options and plans	SW
39	Built-in Camera - Single shot	Y
40	Built in Camera - Video	Y
Field Operational Factors		
41	Camouflage	Likely an option
	Night	N
42	Size	11.2cm x 6.2cm x 1.4cm
43	Weight	130g
44	Stowage	many case options
45	Power	Li-Ion internal, charger
	Battery Life	5hours talk time, 5 hours internet
46	Ruggedness / Meets standards	no standards
	Waterproof	N
	Dirt/Sandproof	N
	Heat Resistant	?
	Cold Resistant	?
	Field Maintenance	Cleaning is possible, parts would just be a unit replacement
47	Means of Operator Input	Alphanumeric keyboard, control keys
	Gloved hand operation	N
	Ports	USB
48	Output	Half VGA+, 65000 colours
	Screen size	480x360pixel
49	Security	Password
50	Readable in all Lighting Conditions	?

Cassiopeia E-105

Housekeeping Functions (internal device functionality, status, and security)		
1	Maintain awareness of sensor status and alarms	SW
	(comments)	
2	Plan storage	SW
3	Development Environment	Windows CE 3.0
	Can additional programmable software be downloaded?	Y
Mapping Functions (simple display of layers, location coordinates etc)		
4	Reference maps	Y
	(comments)	SW required for vegetation, DTED, and different formats
5	Track own location	Y
6	Track location of blue forces	SW
	(comments)	
7	Track location of enemy forces	SW
	(comments)	
8	Track location of other entities	SW
9	Navigate outdoors en route	Y
	(comments)	Heading, bearing, real-time GPS. SA and route updating would be dependant on SW
10	Manage multiple routes	SW
11	Navigate Indoors	SW
	(comments)	
12	Navigate on Urban Streets	SW
	(comments)	
Editing Functions (adding new features or textual input to the map - mark-up, pin-point, comments, etc)		
13	Manipulate maps	Y
14	Insert notes and/or hand drawn overlays on the digital map	SW
	(comments)	
15	Insert notes and/or hand drawn overlays on photos	SW
	(comments)	
16	Mark-up inaccurate maps	SW
Data Processing and Analysis Functions (additional processes beyond basic mapping e.g. calculations, route planning automation)		
17	Automated Target Designation and Reporting	SW
18	Distribute information to others	SW
19	Ability for multiple people to share a common picture	Approx 2 people could view the screen at once, unit could be passed around, or same image displayed on many units
20	Facilitate mission briefing	SW
21	Plan and Revise Route	SW
	(comments)	
22	Calculate distance between locations	SW
23	Consolidate multiple defensive positions	SW
24	Create and display layout of defensive	SW

	position and firing arcs	
25	Logistics management	SW
26	Weather effects analysis	SW
27	Integrate GIS info with digital planning software	SW
28	Processor	NEC VR4122 @ 131MHz
29	Memory	32MB RAM, 16MB Flash
	Expansion?	CF slot
30	Data Supported	?
	GPS level of accuracy	?
31	Range Finders	N
32	Barcode Scanners	N
Visualization Options (2D, 3D, video, etc)		
33	Reference photos	Y
	(comments)	SW required for overlays
34	Watch Video	SW
	(comments)	
35	User selectable display of entities	SW
36	Collaborative visualization of the operational area	SW
37	Time appreciation	SW
38	Visualize battlespace options and plans	SW
39	Built-in Camera - Single shot	?
40	Built in Camera - Video	?
Field Operational Factors		
41	Camouflage	Likely an option
	Night	N
42	Size	13cm x 8.4cm x 2cm
43	Weight	255g
44	Stowage	?
45	Power	Li-Ion internal, charger
	Battery Life	?
46	Ruggedness / Meets standards	no standards
	Waterproof	N
	Dirt/Sandproof	N
	Heat Resistant	?
	Cold Resistant	?
	Field Maintenance	Cleaning is possible, parts would just be a unit replacement
47	Means of Operator Input	Touch screen, some control keys
	Gloved hand operation	Y
	Ports	USB, Serial
48	Output	TFT, 16BPP
	Screen size	9.9cm diag
49	Security	SW
50	Readable in all Lighting Conditions	?

Hewlett Packard (HP) iPAQ 910 Smartphone

Housekeeping Functions (internal device functionality, status, and security)		
1	Maintain awareness of sensor status and alarms	SW
	(comments)	
2	Plan storage	SW
3	Development Environment	Windows Mobile 6.1 Professional
	Can additional programmable software be downloaded?	Y
Mapping Functions (simple display of layers, location coordinates etc)		
4	Reference maps	Y
	(comments)	SW required for vegetation, DTED, and different formats
5	Track own location	Y
6	Track location of blue forces	SW
	(comments)	
7	Track location of enemy forces	SW
	(comments)	
8	Track location of other entities	SW
9	Navigate outdoors en route	SW
	(comments)	
10	Manage multiple routes	SW
11	Navigate Indoors	SW
	(comments)	
12	Navigate on Urban Streets	SW
	(comments)	
Editing Functions (adding new features or textual input to the map - mark-up, pin-point, comments, etc)		
13	Manipulate maps	Y
14	Insert notes and/or hand drawn overlays on the digital map	SW
	(comments)	
15	Insert notes and/or hand drawn overlays on photos	SW
	(comments)	
16	Mark-up inaccurate maps	SW
Data Processing and Analysis Functions (additional processes beyond basic mapping e.g. calculations, route planning automation)		
17	Automated Target Designation and Reporting	SW
18	Distribute information to others	SW
19	Ability for multiple people to share a common picture	Approx 2 people could view the screen at once, unit could be passed around, or same image displayed on many units
20	Facilitate mission briefing	SW
21	Plan and Revise Route	SW
	(comments)	
22	Calculate distance between locations	SW
23	Consolidate multiple defensive positions	SW
24	Create and display layout of defensive position and firing arcs	SW
25	Logistics management	SW

26	Weather effects analysis	SW
27	Integrate GIS info with digital planning software	SW
28	Processor	Marvell PXA270 @416 MHz
29	Memory	128 MB SDRAM, 256 MB Flash
	Expansion?	1 microSD
30	Data Supported	?
	GPS level of accuracy	?
31	Range Finders	N
32	Barcode Scanners	N
Visualization Options (2D, 3D, video, etc)		
33	Reference photos	Y
	(comments)	SW required for overlays
34	Watch Video	SW
	(comments)	
35	User selectable display of entities	SW
36	Collaborative visualization of the operational area	SW
37	Time appreciation	SW
38	Visualize battlespace options and plans	SW
39	Built-in Camera - Single shot	Y
40	Built in Camera - Video	Y
Field Operational Factors		
41	Camouflage	Likely an option
	Night	N
42	Size	11.4cm x 6.4cm x 1.5cm
43	Weight	154g
44	Stowage	?
45	Power	Li-Ion internal, charger
	Battery Life	?
46	Ruggedness / Meets standards	no standards
	Waterproof	N
	Dirt/Sandproof	N
	Heat Resistant	?
	Cold Resistant	?
	Field Maintenance	Cleaning is possible, parts would just be a unit replacement
47	Means of Operator Input	Touch screen, alphanumeric keyboard
	Gloved hand operation	Y
	Ports	mini USB
48	Output	TFT 320-240 pixel
	Screen size	6.2cm diag
49	Security	SW
50	Readable in all Lighting Conditions	Y

Motorola Clutch i465

Housekeeping Functions (internal device functionality, status, and security)		
1	Maintain awareness of sensor status and alarms	SW
	(comments)	
2	Plan storage	SW
3	Development Environment	?
	Can additional programmable software be downloaded?	Y
Mapping Functions (simple display of layers, location coordinates etc)		
4	Reference maps	Y
	(comments)	SW required for vegetation, DTED, and different formats
5	Track own location	Y
6	Track location of blue forces	SW
	(comments)	
7	Track location of enemy forces	SW
	(comments)	
8	Track location of other entities	SW
9	Navigate outdoors en route	SW
	(comments)	
10	Manage multiple routes	SW
11	Navigate Indoors	SW
	(comments)	
12	Navigate on Urban Streets	SW
	(comments)	
Editing Functions (adding new features or textual input to the map - mark-up, pin-point, comments, etc)		
13	Manipulate maps	Y
14	Insert notes and/or hand drawn overlays on the digital map	SW
	(comments)	
15	Insert notes and/or hand drawn overlays on photos	SW
	(comments)	
16	Mark-up inaccurate maps	SW
Data Processing and Analysis Functions (additional processes beyond basic mapping e.g. calculations, route planning automation)		
17	Automated Target Designation and Reporting	SW
18	Distribute information to others	SW
19	Ability for multiple people to share a common picture	Approx 2 people could view the screen at once, unit could be passed around, or same image displayed on many units
20	Facilitate mission briefing	SW
21	Plan and Revise Route	SW
	(comments)	
22	Calculate distance between locations	SW
23	Consolidate multiple defensive positions	SW
24	Create and display layout of defensive position and firing arcs	SW
25	Logistics management	SW

26	Weather effects analysis	SW
27	Integrate GIS info with digital planning software	SW
28	Processor	?
29	Memory	16MB RAM, 64MB Flash
	Expansion?	N
30	Data Supported	?
	GPS level of accuracy	?
31	Range Finders	N
32	Barcode Scanners	N
Visualization Options (2D, 3D, video, etc)		
33	Reference photos	Y
	(comments)	SW required for overlays
34	Watch Video	SW
	(comments)	
35	User selectable display of entities	SW
36	Collaborative visualization of the operational area	SW
37	Time appreciation	SW
38	Visualize battlespace options and plans	SW
39	Built-in Camera - Single shot	Y
40	Built in Camera - Video	Y
Field Operational Factors		
41	Camouflage	Likely an option
	Night	N
42	Size	?
43	Weight	98.4g
44	Stowage	?
45	Power	Li-Ion internal, charger
	Battery Life	205min
46	Ruggedness / Meets standards	"meets military specs"
	Waterproof	?
	Dirt/Sandproof	?
	Heat Resistant	?
	Cold Resistant	?
	Field Maintenance	Cleaning is possible, parts would just be a unit replacement
47	Means of Operator Input	Alphanumeric keyboard, control keys
	Gloved hand operation	N
	Ports	?
48	Output	TFT
	Screen size	4.5cm
49	Security	SW
50	Readable in all Lighting Conditions	?

Palm Pre

Housekeeping Functions (internal device functionality, status, and security)		
1	Maintain awareness of sensor status and alarms	SW
	(comments)	
2	Plan storage	SW
3	Development Environment	Palm webOS
	Can additional programmable software be downloaded?	Y
Mapping Functions (simple display of layers, location coordinates etc)		
4	Reference maps	Y
	(comments)	SW required for vegetation, DTED, and different formats
5	Track own location	Y
6	Track location of blue forces	SW
	(comments)	
7	Track location of enemy forces	SW
	(comments)	
8	Track location of other entities	SW
9	Navigate outdoors en route	SW
	(comments)	
10	Manage multiple routes	SW
11	Navigate Indoors	SW
	(comments)	
12	Navigate on Urban Streets	SW
	(comments)	
Editing Functions (adding new features or textual input to the map - mark-up, pin-point, comments, etc)		
13	Manipulate maps	Y
14	Insert notes and/or hand drawn overlays on the digital map	SW
	(comments)	
15	Insert notes and/or hand drawn overlays on photos	SW
	(comments)	
16	Mark-up inaccurate maps	SW
Data Processing and Analysis Functions (additional processes beyond basic mapping e.g. calculations, route planning automation)		
17	Automated Target Designation and Reporting	SW
18	Distribute information to others	SW
19	Ability for multiple people to share a common picture	Approx 2 people could view the screen at once, unit could be passed around, or same image displayed on many units
20	Facilitate mission briefing	SW
21	Plan and Revise Route	SW
	(comments)	
22	Calculate distance between locations	SW
23	Consolidate multiple defensive positions	SW
24	Create and display layout of defensive position and firing arcs	SW
25	Logistics management	SW
26	Weather effects analysis	SW
27	Integrate GIS info with digital planning	SW

	software	
28	Processor	?
29	Memory	8GB RAM
	Expansion?	through USB
30	Data Supported	?
	GPS level of accuracy	?
31	Range Finders	N
32	Barcode Scanners	N
Visualization Options (2D, 3D, video, etc)		
33	Reference photos	Y
	(comments)	SW required for overlays
34	Watch Video	SW
	(comments)	
35	User selectable display of entities	SW
36	Collaborative visualization of the operational area	SW
37	Time appreciation	SW
38	Visualize battlespace options and plans	SW
39	Built-in Camera - Single shot	Y
40	Built in Camera - Video	Y
Field Operational Factors		
41	Camouflage	Likely an option
	Night	N
42	Size	10cm x 6cm x 1.7cm
43	Weight	135g
44	Stowage	?
45	Power	Li-Ion internal, charger
	Battery Life	?
46	Ruggedness / Meets standards	no standards
	Waterproof	N
	Dirt/Sandproof	N
	Heat Resistant	?
	Cold Resistant	?
	Field Maintenance	Cleaning is possible, parts would just be a unit replacement
47	Means of Operator Input	Touch screen, control keys
	Gloved hand operation	Y
	Ports	USB
48	Output	24-bit HVGA
	Screen size	7.9cm diag
49	Security	SW
50	Readable in all Lighting Conditions	?

Military-Off-The-Shelf (MOTS) Systems

Black Diamond Switchback

Housekeeping Functions (internal device functionality, status, and security)		
1	Maintain awareness of sensor status and alarms	SW
	(comments)	
2	Plan storage	SW
3	Development Environment	Windows XP Pro, or Vista or Linux
	Can additional programmable software be downloaded?	Y
Mapping Functions (simple display of layers, location coordinates etc)		
4	Reference maps	Y
	(comments)	SW required for vegetation, DTED, and different formats
5	Track own location	SW
6	Track location of blue forces	SW
	(comments)	
7	Track location of enemy forces	SW
	(comments)	
8	Track location of other entities	SW
9	Navigate outdoors en route	SW
	(comments)	
10	Manage multiple routes	SW
11	Navigate Indoors	SW
	(comments)	
12	Navigate on Urban Streets	SW
	(comments)	
Editing Functions (adding new features or textual input to the map - mark-up, pin-point, comments, etc)		
13	Manipulate maps	Y
14	Insert notes and/or hand drawn overlays on the digital map	SW
	(comments)	
15	Insert notes and/or hand drawn overlays on photos	SW
	(comments)	
16	Mark-up inaccurate maps	SW
Data Processing and Analysis Functions (additional processes beyond basic mapping e.g. calculations, route planning automation)		
17	Automated Target Designation and Reporting	SW
18	Distribute information to others	SW
19	Ability for multiple people to share a common picture	Approx 4 people could view the screen at once, unit could be passed around, or same image displayed on many units
20	Facilitate mission briefing	SW
21	Plan and Revise Route	SW
	(comments)	
22	Calculate distance between locations	SW
23	Consolidate multiple defensive positions	SW
24	Create and display layout of defensive	SW

	position and firing arcs	
25	Logistics management	SW
26	Weather effects analysis	SW
27	Integrate GIS info with digital planning software	SW
28	Processor	Celeron 1.0Ghz, 533Mhz FSB
29	Memory	512MB DRAM, 1 GB DDR II DRAM, 2GB DDR II DRAM, 32GB Solid State drive
	Expansion?	Solid State Drive: up to 64GB
30	Data Supported	?
	GPS level of accuracy	?
31	Range Finders	Could add in a port
32	Barcode Scanners	Could add in a port
Visualization Options (2D, 3D, video, etc)		
33	Reference photos	Y
	(comments)	SW required for overlays
34	Watch Video	SW
	(comments)	
35	User selectable display of entities	SW
36	Collaborative visualization of the operational area	SW
37	Time appreciation	SW
38	Visualize battlespace options and plans	SW
39	Built-in Camera - Single shot	Could add in a port
40	Built in Camera - Video	Could add in a port
Field Operational Factors		
41	Camouflage	Y
	Night	N
42	Size	19cm x 14cm x 5.1cm
43	Weight	1.36Kg
44	Stowage	?
45	Power	Li-Ion, rechagable
	Battery Life	?
46	Ruggedness / Meets standards	MIL-STD-810F
	Waterproof	IP-67
	Dirt/Sandproof	IP-67
	Heat Resistant	55C
	Cold Resistant	-20C
	Field Maintenance	Cleaning is possible, parts would just be a unit replacement
47	Means of Operator Input	Touch screen, Alphanumeric keypad
	Gloved hand operation	Y
	Ports	USB 2.0, Type II PCMCIA, Serial port
48	Output	LCD WSVGA
	Screen size	14.2cm diag
49	Security	SW
50	Readable in all Lighting Conditions	Y

Cobham IDSS system - SDTP, SDTT

Housekeeping Functions (internal device functionality, status, and security)		
1	Maintain awareness of sensor status and alarms	Y
	(comments)	"Integrates with a wide range of sensors" - no other details
2	Plan storage	Y
3	Development Environment	Windows XP
	Can additional programmable software be downloaded?	Y
Mapping Functions (simple display of layers, location coordinates etc)		
4	Reference maps	Y
	(comments)	SW required for vegetation, DTED, and different formats
5	Track own location	Y
6	Track location of blue forces	Y
	(comments)	"Comprehensive blue force SA" (no other details)
7	Track location of enemy forces	Y
	(comments)	"Red force picture" (no other details)
8	Track location of other entities	SW
9	Navigate outdoors en route	Y
	(comments)	"Full navigation suite"
10	Manage multiple routes	SW
11	Navigate Indoors	SW
	(comments)	
12	Navigate on Urban Streets	SW
	(comments)	
Editing Functions (adding new features or textual input to the map - mark-up, pin-point, comments, etc)		
13	Manipulate maps	Y
14	Insert notes and/or hand drawn overlays on the digital map	Y
	(comments)	Georeferenced free-hand drawing, create/display overlays
15	Insert notes and/or hand drawn overlays on photos	Y
	(comments)	Create/display overlays
16	Mark-up inaccurate maps	SW
Data Processing and Analysis Functions (additional processes beyond basic mapping e.g. calculations, route planning automation)		
17	Automated Target Designation and Reporting	SW
18	Distribute information to others	SW
19	Ability for multiple people to share a common picture	Approx 2 people could view the screen at once, unit could be passed around, or same image displayed on many units
20	Facilitate mission briefing	SW
21	Plan and Revise Route	Y
	(comments)	"Create/display mission overlays" - specific route planning would be SW
22	Calculate distance between locations	SW

23	Consolidate multiple defensive positions	SW
24	Create and display layout of defensive position and firing arcs	SW
25	Logistics management	SW
26	Weather effects analysis	SW
27	Integrate GIS info with digital planning software	SW
28	Processor	SDT
29	Memory	?
	Expansion?	?
30	Data Supported	?
	GPS level of accuracy	?
31	Range Finders	Posibly could be added in a port?
32	Barcode Scanners	Posibly could be added in a port?
Visualization Options (2D, 3D, video, etc)		
33	Reference photos	Y
	(comments)	
34	Watch Video	SW
	(comments)	
35	User selectable display of entities	SW
36	Collaborative visualization of the operational area	SW
37	Time appreciation	SW
38	Visualize battlespace options and plans	SW
39	Built-in Camera - Single shot	Posibly could be added in a port?
40	Built in Camera - Video	Posibly could be added in a port?
Field Operational Factors		
41	Camouflage	Y
	Night	Y
42	Size	?
43	Weight	?
44	Stowage	?
45	Power	?
	Battery Life	?
46	Ruggedness / Meets standards	?
	Waterproof	?
	Dirt/Sandproof	?
	Heat Resistant	?
	Cold Resistant	?
	Field Maintenance	Cleaning is possible, parts would just be a unit replacement
47	Means of Operator Input	Touch screen, some control keys
	Gloved hand operation	Y
	Ports	connects to radio / GPS unit
48	Output	?
	Screen size	?
49	Security	?
50	Readable in all Lighting Conditions	Y

DRS Technologies, SELEX LRT-440 WPC (Italian "Soldato Futuro")

Housekeeping Functions (internal device functionality, status, and security)		
1	Maintain awareness of sensor status and alarms	SW
	(comments)	
2	Plan storage	SW
3	Development Environment	Windows CE 5.0
	Can additional programmable software be downloaded?	Y
Mapping Functions (simple display of layers, location coordinates etc)		
4	Reference maps	Y
	(comments)	SW required for vegetation, DTED, and different formats
5	Track own location	SW
6	Track location of blue forces	SW
	(comments)	
7	Track location of enemy forces	SW
	(comments)	
8	Track location of other entities	SW
9	Navigate outdoors en route	SW
	(comments)	
10	Manage multiple routes	SW
11	Navigate Indoors	SW
	(comments)	
12	Navigate on Urban Streets	SW
	(comments)	
Editing Functions (adding new features or textual input to the map - mark-up, pin-point, comments, etc)		
13	Manipulate maps	Y
14	Insert notes and/or hand drawn overlays on the digital map	SW
	(comments)	
15	Insert notes and/or hand drawn overlays on photos	SW
	(comments)	
16	Mark-up inaccurate maps	SW
Data Processing and Analysis Functions (additional processes beyond basic mapping e.g. calculations, route planning automation)		
17	Automated Target Designation and Reporting	SW
18	Distribute information to others	SW
19	Ability for multiple people to share a common picture	2 options for displays. Commander: Large screen, Soldier: smaller screen. Approx 4 could view the commander screen, approx 2 could view the soldier screen
20	Facilitate mission briefing	SW
21	Plan and Revise Route	SW
	(comments)	
22	Calculate distance between locations	SW
23	Consolidate multiple defensive positions	SW
24	Create and display layout of defensive position and firing arcs	SW
25	Logistics management	SW
26	Weather effects analysis	SW
27	Integrate GIS info with digital planning	SW

	software	
28	Processor	PXA250, 400Mhz
29	Memory	128MB RAM, 128MB Flash
	Expansion?	?
30	Data Supported	?
	GPS level of accuracy	?
31	Range Finders	Possibly could be added in ports
32	Barcode Scanners	Could be added in ports
Visualization Options (2D, 3D, video, etc)		
33	Reference photos	Y
	(comments)	SW required for overlays
34	Watch Video	SW
	(comments)	
35	User selectable display of entities	SW
36	Collaborative visualization of the operational area	SW
37	Time appreciation	SW
38	Visualize battlespace options and plans	SW
39	Built-in Camera - Single shot	Could be added in ports
40	Built in Camera - Video	Could be added in ports
Field Operational Factors		
41	Camouflage	Y
	Night	N
42	Size	Processor: 10cm x 12cm x 3cm, display 9cm x 12cm x 2.5cm or 15cm x 19cm x 4cm
43	Weight	500g plus 300g or 600g depending on display
44	Stowage	?
45	Power	chargable battery pack
	Battery Life	6 to 24 hours
46	Ruggedness / Meets standards	MIL-STD-810F
	Waterproof	MIL-STD-810F, IP66
	Dirt/Sandproof	MIL-STD-810F, IP67
	Heat Resistant	70 C
	Cold Resistant	-25 C
	Field Maintenance	Cleaning is possible, parts would just be a unit replacement
47	Means of Operator Input	Touch screen, some control keys
	Gloved hand operation	Y
	Ports	Ethernet, USB, RS232
48	Output	
	Screen size	8.9cm (soldier) or 16.3cm (commander) diag
49	Security	?
50	Readable in all Lighting Conditions	?

EADS Warrior 21

This device is part of SMP (Soldier Modernization Program) system. There was no information available for this system. No commercial systems are similar.

Housekeeping Functions (internal device functionality, status, and security)		
1	Maintain awareness of sensor status and alarms	No information
	(comments)	No information
2	Plan storage	No information
3	Development Environment	No information
	Can additional programmable software be downloaded?	No information
Mapping Functions (simple display of layers, location coordinates etc)		
4	Reference maps	No information
	(comments)	No information
5	Track own location	No information
6	Track location of blue forces	No information
	(comments)	No information
7	Track location of enemy forces	No information
	(comments)	No information
8	Track location of other entities	No information
9	Navigate outdoors en route	No information
	(comments)	No information
10	Manage multiple routes	No information
11	Navigate Indoors	No information
	(comments)	No information
12	Navigate on Urban Streets	No information
	(comments)	No information
Editing Functions (adding new features or textual input to the map - mark-up, pin-point, comments, etc)		
13	Manipulate maps	No information
14	Insert notes and/or hand drawn overlays on the digital map	No information
	(comments)	No information
15	Insert notes and/or hand drawn overlays on photos	No information
	(comments)	No information
16	Mark-up inaccurate maps	No information
Data Processing and Analysis Functions (additional processes beyond basic mapping e.g. calculations, route planning automation)		
17	Automated Target Designation and Reporting	No information
18	Distribute information to others	No information
19	Ability for multiple people to share a common picture	No information
20	Facilitate mission briefing	No information
21	Plan and Revise Route	No information
	(comments)	No information
22	Calculate distance between locations	No information
23	Consolidate multiple defensive positions	No information
24	Create and display layout of defensive position and firing arcs	No information
25	Logistics management	No information
26	Weather effects analysis	No information
27	Integrate GIS info with digital planning software	No information

28	Processor	No information
29	Memory	No information
	Expansion?	No information
30	Data Supported	No information
	GPS level of accuracy	No information
31	Range Finders	No information
32	Barcode Scanners	No information
Visualization Options (2D, 3D, video, etc)		
33	Reference photos	No information
	(comments)	No information
34	Watch Video	No information
	(comments)	No information
35	User selectable display of entities	No information
36	Collaborative visualization of the operational area	No information
37	Time appreciation	No information
38	Visualize battlespace options and plans	No information
39	Built-in Camera - Single shot	No information
40	Built in Camera - Video	No information
Field Operational Factors		
41	Camouflage	No information
	Night	No information
42	Size	No information
43	Weight	No information
44	Stowage	No information
45	Power	No information
	Battery Life	No information
46	Ruggedness / Meets standards	No information
	Waterproof	No information
	Dirt/Sandproof	No information
	Heat Resistant	No information
	Cold Resistant	No information
	Field Maintenance	No information
47	Means of Operator Input	No information
	Gloved hand operation	No information
	Ports	No information
48	Output	No information
	Screen size	No information
49	Security	No information
50	Readable in all Lighting Conditions	No information

Elbitsystems (Israel) Military Tactical Computer

Housekeeping Functions (internal device functionality, status, and security)		
1	Maintain awareness of sensor status and alarms	SW
	(comments)	
2	Plan storage	SW
3	Development Environment	Windows 98, 2000, NT
	Can additional programmable software be downloaded?	Y
Mapping Functions (simple display of layers, location coordinates etc)		
4	Reference maps	Y
	(comments)	SW required for vegetation, DTED, and different formats
5	Track own location	SW
6	Track location of blue forces	SW
	(comments)	
7	Track location of enemy forces	SW
	(comments)	
8	Track location of other entities	SW
9	Navigate outdoors en route	SW
	(comments)	
10	Manage multiple routes	SW
11	Navigate Indoors	SW
	(comments)	
12	Navigate on Urban Streets	SW
	(comments)	
Editing Functions (adding new features or textual input to the map - mark-up, pin-point, comments, etc)		
13	Manipulate maps	Y
14	Insert notes and/or hand drawn overlays on the digital map	SW
	(comments)	
15	Insert notes and/or hand drawn overlays on photos	SW
	(comments)	
16	Mark-up inaccurate maps	SW
Data Processing and Analysis Functions (additional processes beyond basic mapping e.g. calculations, route planning automation)		
17	Automated Target Designation and Reporting	SW
18	Distribute information to others	SW
19	Ability for multiple people to share a common picture	Approx 4 people could view the screen at once, unit could be passed around, or same image displayed on many units
20	Facilitate mission briefing	SW
21	Plan and Revise Route	SW
	(comments)	
22	Calculate distance between locations	SW
23	Consolidate multiple defensive positions	SW
24	Create and display layout of defensive position and firing arcs	SW
25	Logistics management	SW
26	Weather effects	SW

	analysis	
27	Integrate GIS info with digital planning software	SW
28	Processor	Pentium III 500MHZ
29	Memory	128MB RAM, HDD 10-40GB
	Expansion?	HDD
30	Data Supported	?
	GPS level of accuracy	?
31	Range Finders	Could add in a port
32	Barcode Scanners	Could add in a port
Visualization Options (2D, 3D, video, etc)		
33	Reference photos	Y
	(comments)	SW required for overlays
34	Watch Video	SW
	(comments)	
35	User selectable display of entities	SW
36	Collaborative visualization of the operational area	SW
37	Time appreciation	SW
38	Visualize battlespace options and plans	SW
39	Built-in Camera - Single shot	Could add in a port
40	Built in Camera - Video	Could add in a port
Field Operational Factors		
41	Camouflage	Y
	Night	N
42	Size	25.4cm x 22.9cm x 8.9cm
43	Weight	5.5Kg
44	Stowage	?
45	Power	24V plus battery backup
	Battery Life	"long life"
46	Ruggedness / Meets standards	MIL-STD-810E,461C,1275
	Waterproof	?
	Dirt/Sandproof	?
	Heat Resistant	55C
	Cold Resistant	-35C
	Field Maintenance	Cleaning is possible, parts would just be a unit replacement
47	Means of Operator Input	Touch screen, full alphanumeric keyboard
	Gloved hand operation	Y
	Ports	2 serial, 2 PCMCIA, parallel, USB, IRDA
48	Output	TFT active SVGA
	Screen size	26.4cm diag
49	Security	SW
50	Readable in all Lighting Conditions	Y

L-3 Communications LDT II

Housekeeping Functions (internal device functionality, status, and security)		
1	Maintain awareness of sensor status and alarms	SW
	(comments)	
2	Plan storage	SW
3	Development Environment	Windows or Vista
	Can additional programmable software be downloaded?	Y
Mapping Functions (simple display of layers, location coordinates etc)		
4	Reference maps	Y
	(comments)	SW required for vegetation, DTED, and different formats
5	Track own location	SW
6	Track location of blue forces	SW
	(comments)	
7	Track location of enemy forces	SW
	(comments)	
8	Track location of other entities	SW
9	Navigate outdoors en route	SW
	(comments)	
10	Manage multiple routes	SW
11	Navigate Indoors	SW
	(comments)	
12	Navigate on Urban Streets	SW
	(comments)	
Editing Functions (adding new features or textual input to the map - mark-up, pin-point, comments, etc)		
13	Manipulate maps	SW
14	Insert notes and/or hand drawn overlays on the digital map	SW
	(comments)	
15	Insert notes and/or hand drawn overlays on photos	SW
	(comments)	
16	Mark-up inaccurate maps	SW
Data Processing and Analysis Functions (additional processes beyond basic mapping e.g. calculations, route planning automation)		
17	Automated Target Designation and Reporting	SW
18	Distribute information to others	SW
19	Ability for multiple people to share a common picture	Approx 2-3 people could view the screen at once, unit could be passed around, or same image displayed on many units
20	Facilitate mission briefing	SW
21	Plan and Revise Route	SW
	(comments)	
22	Calculate distance between locations	SW
23	Consolidate multiple defensive positions	SW
24	Create and display layout of defensive position and firing arcs	SW
25	Logistics management	SW
26	Weather effects analysis	SW

27	Integrate GIS info with digital planning software	SW
28	Processor	Intel Atom, 1.6 GHz
29	Memory	512 to 2GB RAM, 80 to 120GB Hard Disk
	Expansion?	?
30	Data Supported	Versa, Open GL, Direct X10
	GPS level of accuracy	?
31	Range Finders	Could add in a port
32	Barcode Scanners	Could add in a port
Visualization Options (2D, 3D, video, etc)		
33	Reference photos	Y
	(comments)	SW required for overlays
34	Watch Video	SW
	(comments)	
35	User selectable display of entities	SW
36	Collaborative visualization of the operational area	SW
37	Time appreciation	SW
38	Visualize battlespace options and plans	SW
39	Built-in Camera - Single shot	Could add in a port
40	Built in Camera - Video	Could add in a port
Field Operational Factors		
41	Camouflage	Y
	Night	N
42	Size	23 x 12 x 4.5cm
43	Weight	1.5kg
44	Stowage	?
45	Power	External 12VDC and rechargable internal battery
	Battery Life	4.5 hours
46	Ruggedness / Meets standards	1.2 m drop on all faces
	Waterproof	rain: 250mm/hour for 1 hour. Fog or mist: 5% to 95%
	Dirt/Sandproof	1.1 g/cm @ 26m/sec for 1 hour
	Heat Resistant	51C
	Cold Resistant	-20C
	Field Maintenance	Cleaning is possible, parts would just be a unit replacement
47	Means of Operator Input	Touch screen, some control keys
	Gloved hand operation	Y
	Ports	Serial, USB, Ethernet, Rs-232, RS-423, USB 2.0, 10/100Base-T
48	Output	WSXGA
	Screen size	14.2cm diag
49	Security	SW
50	Readable in all Lighting Conditions	Y

Northrop Grumman Soldier Link System (SLS)

Housekeeping Functions (internal device functionality, status, and security)		
1	Maintain awareness of sensor status and alarms	SW
	(comments)	
2	Plan storage	SW
3	Development Environment	?
	Can additional programmable software be downloaded?	N
Mapping Functions (simple display of layers, location coordinates etc)		
4	Reference maps	Y
	(comments)	SW required for vegetation, DTED, and different formats
5	Track own location	SW
6	Track location of blue forces	SW
	(comments)	
7	Track location of enemy forces	SW
	(comments)	
8	Track location of other entities	SW
9	Navigate outdoors en route	SW
	(comments)	
10	Manage multiple routes	SW
11	Navigate Indoors	SW
	(comments)	
12	Navigate on Urban Streets	SW
	(comments)	
Editing Functions (adding new features or textual input to the map - mark-up, pin-point, comments, etc)		
13	Manipulate maps	Y
14	Insert notes and/or hand drawn overlays on the digital map	SW
	(comments)	
15	Insert notes and/or hand drawn overlays on photos	SW
	(comments)	
16	Mark-up inaccurate maps	SW
Data Processing and Analysis Functions (additional processes beyond basic mapping e.g. calculations, route planning automation)		
17	Automated Target Designation and Reporting	SW
18	Distribute information to others	SW
19	Ability for multiple people to share a common picture	Approx 2-3 people could view the screen at once, unit could be passed around, or same image displayed on many units
20	Facilitate mission briefing	SW
21	Plan and Revise Route	SW
	(comments)	
22	Calculate distance between locations	SW
23	Consolidate multiple defensive positions	SW
24	Create and display layout of defensive position and firing arcs	SW
25	Logistics management	SW
26	Weather effects analysis	SW

27	Integrate GIS info with digital planning software	SW
28	Processor	Atom Z530
29	Memory	?
	Expansion?	?
30	Data Supported	?
	GPS level of accuracy	2.5m
31	Range Finders	Could add in a port
32	Barcode Scanners	Could add in a port
Visualization Options (2D, 3D, video, etc)		
33	Reference photos	Y
	(comments)	SW required for overlays
34	Watch Video	SW
	(comments)	
35	User selectable display of entities	SW
36	Collaborative visualization of the operational area	SW
37	Time appreciation	SW
38	Visualize battlespace options and plans	SW
39	Built-in Camera - Single shot	Could add in a port
40	Built in Camera - Video	Could add in a port
Field Operational Factors		
41	Camouflage	N
	Night	Y - shielded eyecup for night operations
42	Size	
43	Weight	?
44	Stowage	Conformal computer case (on back), belt with keyboard and display
45	Power	Li-145 batteries
	Battery Life	24hours
46	Ruggedness / Meets standards	?
	Waterproof	?
	Dirt/Sandproof	?
	Heat Resistant	?
	Cold Resistant	?
	Field Maintenance	Cleaning is possible, parts would just be a unit replacement
47	Means of Operator Input	Alphanumeric keyboard, touch screen with some control keys
	Gloved hand operation	Y
	Ports	?
48	Output	?
	Screen size	16.5cm diag
49	Security	?
50	Readable in all Lighting Conditions	Y- shielded eyecup for brightness shielding

OSI Geospatial / Raytheon DC4S product family, Hand-held for dismounted infantry: Assaulter. "COTS hardware with embedded GPS. e.g. Trimble Nomad rugged PDA"

Housekeeping Functions (internal device functionality, status, and security)		
1	Maintain awareness of sensor status and alarms	SW
	(comments)	
2	Plan storage	SW
3	Development Environment	Windows Mobile 6.1
	Can additional programmable software be downloaded?	Y
Mapping Functions (simple display of layers, location coordinates etc)		
4	Reference maps	Y
	(comments)	SW required for vegetation, DTED, and different formats
5	Track own location	SW
6	Track location of blue forces	Y
	(comments)	Location of team leader, team members. Status for man down, lost communications
7	Track location of enemy forces	Y
	(comments)	"location of enemy forces" (no other details)
8	Track location of other entities	SW
9	Navigate outdoors en route	SW
	(comments)	
10	Manage multiple routes	SW
11	Navigate Indoors	SW
	(comments)	
12	Navigate on Urban Streets	SW
	(comments)	
Editing Functions (adding new features or textual input to the map - mark-up, pin-point, comments, etc)		
13	Manipulate maps	SW
14	Insert notes and/or hand drawn overlays on the digital map	SW
	(comments)	
15	Insert notes and/or hand drawn overlays on photos	SW
	(comments)	
16	Mark-up inaccurate maps	SW
Data Processing and Analysis Functions (additional processes beyond basic mapping e.g. calculations, route planning automation)		
17	Automated Target Designation and Reporting	SW
18	Distribute information to others	SW
19	Ability for multiple people to share a common picture	Approx 2 people could view the screen at once, unit could be passed around, or same image displayed on many units
20	Facilitate mission briefing	SW
21	Plan and Revise Route	SW
	(comments)	
22	Calculate distance between locations	SW
23	Consolidate	SW

	multiple defensive positions	
24	Create and display layout of defensive position and firing arcs	SW
25	Logistics management	SW
26	Weather effects analysis	SW
27	Integrate GIS info with digital planning software	SW
28	Processor	Intel PXA255 Xscale CPU @ 400 MHz
29	Memory	? RAM, 256 MB Flash
	Expansion?	1 type I slot, 1 type II slot
30	Data Supported	?
	GPS level of accuracy	2 to 5m
31	Range Finders	Possibly could be added in ports
32	Barcode Scanners	Could be added in ports
Visualization Options (2D, 3D, video, etc)		
33	Reference photos	Y
	(comments)	SW required for overlays
34	Watch Video	Y
	(comments)	"near-streaming video"
35	User selectable display of entities	SW
36	Collaborative visualization of the operational area	SW
37	Time appreciation	SW
38	Visualize battlespace options and plans	SW
39	Built-in Camera - Single shot	Could be added in ports
40	Built in Camera - Video	Could be added in ports
Field Operational Factors		
41	Camouflage	Likely an option
	Night	N
42	Size	22.5cm x 9.5cm x 4.5cm
43	Weight	560 g
44	Stowage	?
45	Power	Internal, rechargable
	Battery Life	?
46	Ruggedness / Meets standards	Y: meets MIL-STD-810F
	Waterproof	Y: IP67
	Dirt/Sandproof	Y: IP67
	Heat Resistant	50 C
	Cold Resistant	-10 C
	Field Maintenance	Cleaning is possible, parts would just be a unit replacement
47	Means of Operator Input	Touch screen, some control keys
	Gloved hand operation	Y
	Ports	RS-232, USB
48	Output	240 x 320 pixel, 1/4 VGA, colour, TFT with LED front light
	Screen size	? ~10cm diag
49	Security	SW
50	Readable in all Lighting Conditions	Y

Rheinmetall IC4U

Housekeeping Functions (internal device functionality, status, and security)		
1	Maintain awareness of sensor status and alarms	SW
	(comments)	
2	Plan storage	SW
3	Development Environment	Linux
	Can additional programmable software be downloaded?	Y
Mapping Functions (simple display of layers, location coordinates etc)		
4	Reference maps	Y
	(comments)	SW required for vegetation, DTED, and different formats
5	Track own location	SW
6	Track location of blue forces	SW
	(comments)	
7	Track location of enemy forces	SW
	(comments)	
8	Track location of other entities	SW
9	Navigate outdoors en route	SW
	(comments)	
10	Manage multiple routes	SW
11	Navigate Indoors	SW
	(comments)	
12	Navigate on Urban Streets	SW
	(comments)	
Editing Functions (adding new features or textual input to the map - mark-up, pin-point, comments, etc)		
13	Manipulate maps	SW
14	Insert notes and/or hand drawn overlays on the digital map	SW
	(comments)	
15	Insert notes and/or hand drawn overlays on photos	SW
	(comments)	
16	Mark-up inaccurate maps	SW
Data Processing and Analysis Functions (additional processes beyond basic mapping e.g. calculations, route planning automation)		
17	Automated Target Designation and Reporting	SW
18	Distribute information to others	SW
19	Ability for multiple people to share a common picture	Approx 2-3 people could view the "wide viewing angle" screen at once, unit could be passed around, or same image displayed on many units
20	Facilitate mission briefing	SW
21	Plan and Revise Route	SW
	(comments)	
22	Calculate distance between locations	SW
23	Consolidate multiple defensive positions	SW
24	Create and display layout of defensive position and firing arcs	SW
25	Logistics management	SW

26	Weather effects analysis	SW
27	Integrate GIS info with digital planning software	SW
28	Processor	600-MhZ ARM
29	Memory	256MB RAM, 256MB Flash
	Expansion?	multiple ports, SDHC card slot, expansion connector for firmware update
30	Data Supported	?
	GPS level of accuracy	?
31	Range Finders	Could add in a port
32	Barcode Scanners	Could add in a port
Visualization Options (2D, 3D, video, etc)		
33	Reference photos	Y
	(comments)	SW required for overlays
34	Watch Video	SW
	(comments)	
35	User selectable display of entities	SW
36	Collaborative visualization of the operational area	SW
37	Time appreciation	SW
38	Visualize battlespace options and plans	SW
39	Built-in Camera - Single shot	Could add in a port
40	Built in Camera - Video	Could add in a port
Field Operational Factors		
41	Camouflage	Y
	Night	N
42	Size	hand-held: 18.2 x 9.1 x 3.3cm, computer: 17 x 10.8 x 3.7cm
43	Weight	hand-held: 350g, computer: 400g
44	Stowage	Easy integration with MOLLE
45	Power	1 Battery Input (10.8VDC), 1 external input (10.8VDC)
	Battery Life	?
46	Ruggedness / Meets standards	MIL-STD 810F
	Waterproof	IP67, MIL-STD 810F
	Dirt/Sandproof	IP67, MIL-STD 810F
	Heat Resistant	60C
	Cold Resistant	-32C
	Field Maintenance	Cleaning is possible, parts would just be a unit replacement
47	Means of Operator Input	Touch screen, some control keys
	Gloved hand operation	Y
	Ports	USB 2.0, 1 IEEE 802.3 Ethernet, EIA-232, RGB output, SDHC card slot,
48	Output	AMOLED display, 16M colour, wide viewing angle, high contrast, anti-glare
	Screen size	10.9cm diag
49	Security	SW
50	Readable in all Lighting Conditions	Y

Rockwell Collins DAGR

Housekeeping Functions (internal device functionality, status, and security)		
1	Maintain awareness of sensor status and alarms	N
	(comments)	
2	Plan storage	N
3	Development Environment	?
	Can additional programmable software be downloaded?	N - just communicate with PC for maps
Mapping Functions (simple display of layers, location coordinates etc)		
4	Reference maps	Y
	(comments)	Terrain, contours, features, roadways, key landmarks, direction N;
5	Track own location	Y
6	Track location of blue forces	N
	(comments)	
7	Track location of enemy forces	N
	(comments)	
8	Track location of other entities	N
9	Navigate outdoors en route	Y
	(comments)	Heading, bearing, real-time GPS.
10	Manage multiple routes	N
11	Navigate Indoors	Y
	(comments)	Possibly import digital floor layout and display own GPS location, heading, and bearings to objects
12	Navigate on Urban Streets	Y
	(comments)	Possibly import street layout and display own GPS location, heading, and bearings to objects
Editing Functions (adding new features or textual input to the map - mark-up, pin-point, comments, etc)		
13	Manipulate maps	Y
14	Insert notes and/or hand drawn overlays on the digital map	N
	(comments)	
15	Insert notes and/or hand drawn overlays on photos	N
	(comments)	
16	Mark-up inaccurate maps	N
Data Processing and Analysis Functions (additional processes beyond basic mapping e.g. calculations, route planning automation)		
17	Automated Target Designation and Reporting	N
18	Distribute information to others	N
19	Ability for multiple people to share a common picture	Approx 2 people could view the screen at once, unit could be passed around, or same image displayed on many units
20	Facilitate mission briefing	N
21	Plan and Revise Route	Y
	(comments)	Has route planning SW with capabilities including: Display

		maps, terrain, route, bearing, distance to waypoints, contours of the ground, prominent features (e.g. roads, bodies of water)
22	Calculate distance between locations	N
23	Consolidate multiple defensive positions	N
24	Create and display layout of defensive position and firing arcs	N
25	Logistics management	N
26	Weather effects analysis	N
27	Integrate GIS info with digital planning software	N
28	Processor	?
29	Memory	999 waypoints, 5 moving waypoints, 15 routes
	Expansion?	N
30	Data Supported	vector, raster, satellite, and bitmap
	GPS level of accuracy	2.28 to 10.5 m
31	Range Finders	Direct data port to Laser Range Finder
32	Barcode Scanners	N
Visualization Options (2D, 3D, video, etc)		
33	Reference photos	Y
	(comments)	no overlays
34	Watch Video	N
	(comments)	
35	User selectable display of entities	N
36	Collaborative visualization of the operational area	N
37	Time appreciation	N
38	Visualize battlespace options and plans	N
39	Built-in Camera - Single shot	N
40	Built in Camera - Video	N
Field Operational Factors		
41	Camouflage	Y
	Night	N
42	Size	16.1cm x 8.8cm x 4cm
43	Weight	454 g
44	Stowage	Nylon case available
45	Power	4 AA
	Battery Life	14 hours
46	Ruggedness / Meets standards	?
	Waterproof	no standard, "immersible to 1m"
	Dirt/Sandproof	?
	Heat Resistant	70 C
	Cold Resistant	-32 C
	Field Maintenance	Cleaning is possible, parts would just be a unit replacement
47	Means of Operator Input	Control keys
	Gloved hand operation	?
	Ports	RS232,RS422, ICD-GPS-153 compliant, NMEA-0183
48	Output	
	Screen size	7.3cm diag
49	Security	Selective Availability/Anti-Spoofing Module (SAASM) security
50	Readable in all Lighting Conditions	Y

Annex 3 – Workshop Plan

Background

Defence Research and Development Canada (DRDC) has a new Applied Research Project on the evaluation of human factors issues associated with geospatial data visualization in a mobile WebGIS environment. This project will investigate the current mobile GIS system capabilities and human factors issues associated with the effective visualization and processing of large volumes of geospatial data on handheld devices. Issues like display size, day and night visualization and system interoperability can affect the usability and utility of mobile GIS systems during military operations.

The first phase of the Test bed Evaluation for the Assessment of Geospatial Data Visualization in Mobile WebGIS Environment project intends to answer the questions of,

1. What are the human factors associated with geospatial data visualization in a mobile GIS environment?
2. What are the limitations with using handheld mobile GIS interfaces?
3. What are the capabilities and functionality of hardware and software in the market?
4. What are the circumstances in which the CF could benefit from a GIS system?
5. What are the best methods for evaluating human factors issues under those circumstances?

To date, an extensive review of recent literature on the use of mobile GIS systems has been completed. The literature review focused on identifying the sets of operator tasks with details about how and where mobile GIS systems could be used in military operations. These sets of operator tasks will be used as a starting point for discussion with Subject Matter Experts (SMEs) at a one-day workshop.

Workshop Objectives

A one-day workshop is planned for Tuesday October 27, 2009 with Canadian Forces SMEs, industry SMEs, DRDC scientific authorities, and Human*systems*® input coordinators. The attendees will be "future thinkers" related to geographic information systems in the military.

The objective of the workshop is to identify and prioritize the relevant human factors issues related to the use of mobile GIS systems in an operational environment. As a follow-on to the workshop, the issues identified will be developed by Human*systems*® ® into scenarios and an experimental plan will be created.

Workshop Agenda

The workshop will follow a structured approach, running from 10am to 4pm with a 1 hour break for lunch. The workshop will commence with an overview of objectives and the work completed on this project to date. This will be followed by both high level and detailed discussions about the human factors issues related to mobile GIS systems. Finally, the issues will be prioritized and the workshop will be wrapped up. Figure 1 presents an outline of the workshop.

Table 1 presents a workshop timetable. Each of the topics are expanded upon below.

Table 12: Workshop Timetable

Agenda (Presenter)	Estimated Start Time (Duration)
Meeting Kickoff	1000
Round Table Introductions (Human*systems*® ®)	1000 (10 minutes)
Goals and Objectives for the workshop (Human*systems*®)	1010 (10 minutes)
Future Plan of the project (Defence R&D Canada)	1020 (10 minutes)
Task and Capability Listings (Human*systems*®)	1030 (20 minutes)
High Level Utility Factors (Human*systems*®)	1050 (40 minutes)
Additional Factors Discussion (Human*systems*®)	1130 (30 minutes)
Lunch	1200 (1 hour)
The Factors in detail (Human*systems*®)	1300 (2 hours)
Prioritization of issues (Human*systems*®)	1500 (45 minutes)
Wrap-up (Human*systems*®)	1545 (15 minutes)
Meeting Ends	1600

1. Introductions

After some brief kickoff words, Human*systems*® will lead round table introductions in order to familiarise attendees with each other.

This time will also include going through the day's agenda, schedule, and administrative considerations (e.g., washroom locations, food options, etc).

2. Goals and Objectives for the workshop

Human*systems*® will lay out what is hoped will be accomplished during the course of the day. The main objective is to identify new functionality and/or tasks that land force soldiers cannot do now, but would like the ability to do if provided with the proper mobile GIS systems. This may involve enhancements to current tasks or the identification of new tasks in the operational environment.

3. Future Plan of the Project

DRDC will present a vision about where the project is looking to go the future. This includes proposing plans for one (or more) Advanced Research Projects based on the findings of this current project.

4. Task Listings

Human*systems*® will briefly present the task/capabilities listing work performed thus far in the project. This includes the tasks and capabilities listing (Table 2) found during the literature review. Further explanations about the process, literature reviewed and hardware systems mapped will also be included.

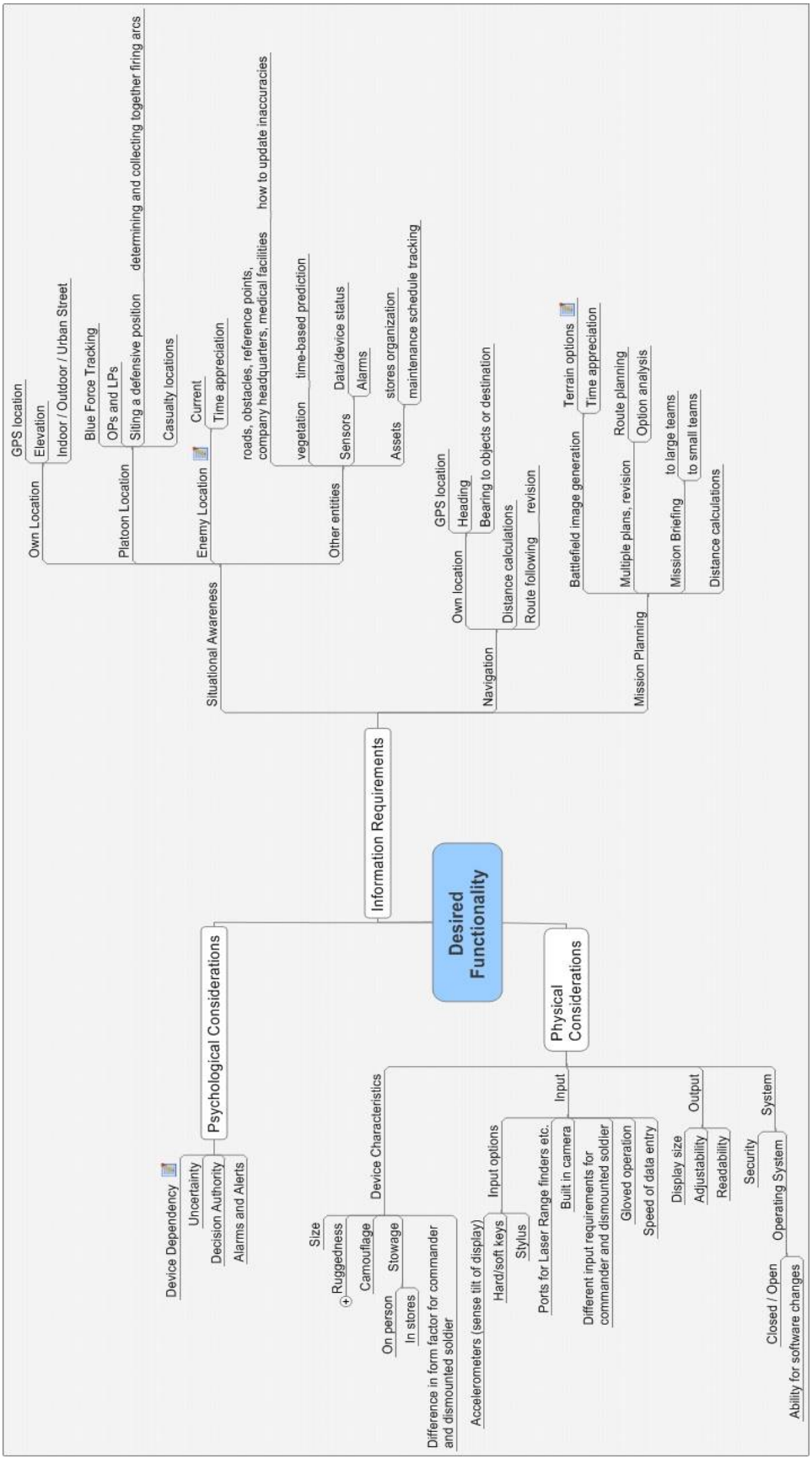
Table 13: Tasks and Capabilities

Mapping Functions (simple display of layers, location coordinates etc)	
1	Reference maps
2	Track own location
3	Track location of blue forces
4	Track location of enemy forces
5	Track location of other entities
6	Navigate outdoors en route
7	Manage multiple routes
8	Navigate Indoors
9	Navigate on Urban Streets
Editing Functions (adding new features or textual input to the map - mark-up, pin-point, comments, etc)	
10	Navigate within maps
11	Insert notes and/or hand drawn overlays on the digital map
12	Insert notes and/or hand drawn overlays on photos
13	Mark-up inaccurate maps
Data Processing and Analysis Functions (additional processes beyond basic mapping e.g., calculations, route planning automation)	
14	Automated Target Designation and Reporting
15	Distribute information to others
16	Ability for multiple people to share a common picture
17	Facilitate mission briefing
18	Plan and Revise Route
19	Calculate distance between locations
20	Consolidate multiple defensive positions
21	Create and display layout of defensive position and firing arcs
22	Logistics management
23	Weather effects analysis
24	Integrate GIS info with digital planning software
25	Processor
26	Memory
27	Data Supported
28	Range Finders

29	Barcode Scanners
Housekeeping Functions (internal device functionality, status, and security)	
30	Maintain awareness of sensor status and alarms
31	Plan storage
32	Development Environment
Visualisation Options (2D, 3D, video, etc)	
33	Reference photos
34	Watch Video
35	User selectable display of entities
36	Collaborative visualization of the operational area
37	Time appreciation
38	Visualize battlespace options and plans
39	Built-in Camera - Single shot
40	Built in Camera - Video
Field Operational Factors	
41	Camouflage
42	Size
43	Weight
44	Stowage
45	Power
46	Ruggedness / Meets standards
47	Means of Operator Input
48	Output
49	Security
50	Readable in all Lighting Conditions

5. High Level Utility Factors

Human*systems*® will present the higher level issues that seem to cut across a number of the task and capability listings. This will include the issues as outlined by the Desired Functionality mindmap (next page). This Mindmap will serve as the starting point for rest of the days discussions.


Desired Functionality
Information Requirements
Psychological Considerations
Device Dependency
Uncertainty
Decision Authority
Alarms and Alerts
Physical Considerations
Device Characteristics
Size
Ruggedness
Camouflage
On person
In stores
Stowage
Difference in form factor for commander and dismounted soldier
Input
Input options
Accelerometers (sense tilt of display)
Hard/soft keys
Stylus
Ports for Laser Range finders etc.
Built in camera
Different input requirements for commander and dismounted soldier
Gloved operation
Speed of data entry
Output
Display size
Adjustability
Readability
System
Security
Operating System
Closed / Open
Ability for software changes
Situational Awareness
Own Location
GPS location
Elevation
Indoor / Outdoor / Urban Street
Platoon Location
Blue Force Tracking
OPs and LPs
Siting a defensive position
determining and collecting together firing arcs
Casualty locations
Enemy Location
Current
Time appreciation
Other entities
roads, obstacles, reference points, company headquarters, medical facilities
how to update inaccuracies
vegetation
time-based prediction
Sensors
Data/device status
Alarms
Assets
stores organization
maintenance schedule tracking
Navigation
Own location
GPS location
Heading
Bearing to objects or destination
Distance calculations
Route following
revision
Mission Planning
Battlefield image generation
Terrain options
Time appreciation
Multiple plans, revision
Route planning
Option analysis
Mission Briefing
to large teams
to small teams
Distance calculations

6. Additional Factors Discussion

Human*systems*® will lead a discussion about the issues to include additional issues and ensure the listing is complete. Also, future soldier tasks will be discussed with respect to mobile GIS capabilities (i.e., what tasks is a soldier in 2020 likely to perform? How would the capability of a mobile GIS device change?)

This session will be followed by a one hour lunch break.

7. Detailed Issues

Human*systems*® will lead a detailed walk through each of the issues identified, focusing on contextual considerations, operational experience, and the general needs of the users. This will be done using the Mindmap to lead the general discussion as well as the addition of probing questions.

8. Prioritization

Human*systems*® will guide the group through a prioritization task in order to identify which issues are highest priorities.

9. Wrap-up

Human*systems*®will solicit final comments and thoughts about the workshop. Once all attendees have inputted their final thoughts the workshop will be officially ended.

Annex 4 – Mobile Geospatial Visualization Workshop Minutes

Note: That this serves as a transcript of what was discussed during the workshop. As such, some terminology may be used differently than defined throughout the rest of this report.

Date: Tuesday 27 October 2009

Time: 1000-1600

Attendees:

NAME	ORGANIZATION
Rifaat Abdalla	DRDC
Sharon McFadden	DRDC
LCol Mike Bodner	DSTL2
Capt Alain Dionne	ISSP
Capt Andy Anderson	ISSP
Doug Palmer	ISSP
Robert Balma	DSSPM 3-7
David Tack	Human*systems*®
Michael Matthews	Human*systems*®
Lisa Rehak	Human*systems*®

Agenda:

#	ITEM (PRESENTER)	START - DURATION
-	Meeting Kickoff	10:00am
1	Round Table Introductions (Human*systems*®)	10:00am – 10
2	Future Plan of the project (DRDC)	10:10am – 10
3	Workshop Goals and Objectives (Human*systems*®)	10:20am – 10
4	Task and Capability Listings (Human*systems*®)	10:30am – 15
5	High Level Utility Factors (Human*systems*®)	10:45am – 45
6	Additional Factors Discussion (Human*systems*®®)	11:30am – 30
-	Lunch	12:00pm – 1 hour
7	The Factors in detail (Human*systems*®)	1:00pm – 2 hours
8	Prioritization of issues (Human*systems*®)	3:00pm – 45 minutes
9	Wrap-up (Human*systems*®)	3:45pm – 15 minutes
-	Meeting Ends	4:00pm

Discussion Notes

#	TOPIC
1	**Round Table Introductions (**Human*systems*®**)** HSI® initiated a round of introductions where each attendee stated their position, organization and role in participating in the workshop.
2	**Future Plan of the project (DRDC)** DRDC Toronto delivered a presentation that detailed background, progress and status of the current project. Questions from attendees initiated discussions about project funding and thrusts. The future direction of the project was also presented.
3	**Workshop Goals and Objectives (**Human*systems*®**)** HSI® presented some administrative details, as well as the goals and objectives of the workshop: To set priorities for a DRDC research program 1. Understand and prioritize human factors issues related to the use of mobile GIS systems in the CF 2. Identify new functionality and/or tasks that land force soldiers cannot do now, but would like the ability to do The three categories of focus concerning major areas that impact mobile GIS were also introduced: • Information/Task requirements • Psychological Considerations • Physical Considerations
4	**Task and Capability Listings (**Human*systems*®**)** HSI® briefly walked through the task and capability listing that was developed and refined in the first phases of the project. The following tasks were presented: *Mapping Functions (simple display of layers, location coordinates etc)* 1 Reference maps 2 Track own location 3 Track location of blue forces 4 Track location of enemy forces 5 Track location of other entities 6 Navigate outdoors en route

	7 Manage multiple routes
	8 Navigate Indoors
	9 Navigate on Urban Streets
	Editing Functions (adding new features or textual input to the map - mark-up, pin-point, comments, etc)
	10 Manipulate maps
	11 Insert notes and/or hand drawn overlays on the digital map
	12 Insert notes and/or hand drawn overlays on photos
	13 Mark-up inaccurate maps
	Data Processing and Analysis Functions (additional processes beyond basic mapping)
	14 Automated Target Designation and Reporting
	15 Distribute information to others
	16 Ability for multiple people to share a common picture
	17 Facilitate mission briefing
	18 Plan and Revise Route
	19 Calculate distance between locations
	20 Consolidate multiple defensive positions
	Data Processing and Analysis Functions (additional processes beyond basic mapping
	21 Create and display layout of defensive position and firing arcs
	22 Logistics management
	23 Weather effects analysis
	24 Integrate GIS info with digital planning software
	25 Processor
	26 Memory
	27 Data Supported
	28 Range Finders
	29 Barcode Scanners
	Housekeeping Functions (internal device functionality, status, and security)
	30 Maintain awareness of sensor status and alarms
	31 Plan storage
	32 Development Environment
	Visualization Options (2D, 3D, video, etc)
	33 Reference photos

	34 Watch Video 35 User selectable display of entities 36 Collaborative visualization of the operational area 37 Time appreciation 38 Visualize battlespace options and plans 39 Built-in Camera - Single shot 40 Built in Camera – Video *Field Operational Factors* 41 Camouflage 42 Size 43 Weight 44 Stowage 45 Power 46 Ruggedness / Meets standards 47 Means of Operator Input 48 Output 49 Security 50 Readable in all Lighting Conditions Attendees asked a few clarifying questions about certain tasks. No additional tasks were identified as missing from the list.
5	**High Level Utility Factors (**Human*systems*®**)** A mind map was distributed to all attendees. This document was used as a framework for discussions for the rest of the day and was added to and changed. The original mind map that initiated the discussions can be found in Annex 5. The resulting mind map that was created during the discussions can be found in Annex 6.
6	**Additional Factors Discussion (**Human*systems*®**)** Attendees were initially asked to about additional considerations that were not included on the mindmap. The only addition added at this time was "Training", under psychological considerations.
7a	**The Factors in detail (**Human*systems*®**)** Detailed discussions then began based on the information in the mindmap (Annex 6). Mind map topics that initiated the discussion are included as the first portion of the heading (e.g., Mind Map Topic: Subtopic). Topics not directly related to the mind map are listed under "General:" Information bounced around a great deal – but the following topic areas were discussed. Navigation: Route Planning: Change Detection • There is a need to see changes (e.g., losses) and know what the impact of those

changes will be on the plan. That information needs to be known quickly. Sometimes how the picture has changed is not as clear as it could be.

Navigation: H Hour[11]

- Timing information can lead to confusion. All the time information is based on H hour – which can be constantly changing. It would be useful to enter in an H hour and a list of timings based on that H hour, which can be sent to everyone. Then if H hour changes, you make one change (i.e., change H hour) and the system auto updates all the timing information for the plan.
- The system could also have time related flags. If it becomes impossible to make the H hour, that is a significant event – and it should be flagged to the commander.
    - Further, tasking information could be sent to other sections due to the fact that one section will not meet their H hour.
- This would involve creating a time component for the planned route and then having automatic comparisons between actual events (i.e., during execution) and planned events.
- If there is a group that is pushing through too fast they will soon be unsupported and that should be flagged also

General: Command and Control

- A soldier's Command Post can be a day away.
- There is a need for separate but integrated tools for planning vs. execution. There is also a need for different capabilities at different levels of command, e.g., to turn on/off the certain information.
- Ideally, one wants C2 process to happen faster to enable quicker impacts on the battle field. To do this, you want all soldiers to have the functionality of Google maps - from lower tactical to all the way up the chain of command.
- The customization of information for different command levels should be guided by the fact that orders are issued one level down, but planning occurs two down).
- The information from intelligence is built up and is used to help determine where to deploy troops to. There is a lot of information (istar, indirect fire, fast air, etc). All this type of information is linked from HQ to HQ.
    - To link all this, you need information inputted by a user somewhere
- The timing of information passed between command levels is laid out in the battle rhythm
    - Top/down – briefings occur 2 times per day or once per day.
    - Subunits report a daily SITREP (including logistics, etc).

[11] *H-Hour is the time of day at which an attack, landing, or other military operation is scheduled to begin* http://www.encyclopedia.com/doc/1O999-hhour.html

- Bn receives one SITREP per day.
- During an emergency (e.g., if there is a car bomb), then this information is communicated instantly.

- A section commander has overlays on his/her map. He/she then transmits that information up to higher command once they have collected all the information together
- There needs to be a high level of reliability for these systems to be on a soldier. The effectiveness of the soldier on the ground needs to be more precise and faster - or else the military would be wiser to use other weapons systems that involve less risk to the lives of soldiers (e.g., air assaults).
  - Weapons system operator: If he/she is looking at a handheld system then they are not looking at where they should be.
- Too much information will stop the C2 process. Need people to be able to process the information, by filtering at multiple levels of the system.

Situation Awareness: Current Time

- There is a great deal of time wasted on radios to identify the time that things happened at, if time can be saved by auto logging information with timestamps that would be beneficial.

Mission Planning: Terrain Analysis: Inter-visibility

- This is a new functionality that is becoming more and more important. It involves determining what points (based on altitude and terrain layout) are visible or not from different positions.

General: Current System Limitations that will affect future implementations

- Push systems are failing because of latency, bandwidth, packet sizes, etc. Soldiers don't need to know where someone was 2 hours ago. They need to know where they are now.

Information Requirements: What information do dismounted soldiers actually need?

- A soldier doesn't need to look at a map all the time. He/she has 2 bosses (section leader and second in command). A soldier knows what his/her plan is for the next 48 hrs from mission briefings. This is the main source of his/her SA.
  - It would be beneficial to give them a tool (blue force tracking, etc) perhaps on his/her weapons systems, making it easier for them to put a red dot on the enemy
- Dismounted soldier may not need all the terrain analysis information. It is important for a commander who is planning, but it is not necessarily needed at the soldier level.
- Could have a friendly blue dot – but would need to attach information about who that actually is, their health state, what weapons they have on them, etc. That would be useful to know.

- Currently, command posts have internet and can get Google satellite information. However, at levels below the command post (i.e., platoon, individual soldier, etc) they do not have access to any of this information.
    - Perhaps for a specific operation a platoon commander will have access to satellite images, predator feeds, etc. But this is not the norm.
    - Generally, he/she gets one copy of a satellite image. This image is almost always from a different perspective than the commander is expected to make the approach from. Ideally, these images should be oriented from the perspective of how they are going to approach the target location.

Information Annotation: Marking errors on maps and making changes

- Agreed that if soldiers have intelligence information (i.e., with the enemy marked as being located here and here) and then a solder on the ground sees that the enemy information has changed, he/she needs to be able to mark or share that change/inaccuracy
- If the map is wrong, a MCpl or a Sgt in a sniper team could photograph and document the error.
    - Cameras were given out recently. It has been found that these cameras are used in many various ways (use around corner, etc).
- Those who would actually make changes would be operators in the All Source Intelligence Cell (ASIC). These personnel are at the Bn level.
    - Information could travel around through a SITREP (runner, tech, etc).

Mission Planning: Siting: Digital Range Cards

- Range cards can take up to a day to do manually. Digitally it takes only 30 minutes. It serves as a good form of mission planning visualization also

General: ISSP

- *ISSP: S&T questions for build 3 - 5, 10, 15 years - could be good to attend C4I workshop.*
    - Trying to look out 5, 10, 15 years to understand the technical possibilities and lay out a roadmap
    - Though we are separating things out into phases, those phases are going to start to interconnect. For example, intervisibility is part of the prototyped systems of some nations already though is not officially included until phase 2.
        - They took a simple idea and translated it into other capabilities (e.g., their system had a tactical battlefield analysis tool that looked at high ground vs. low ground and suggested good and bad locations).
        - This Israeli system could tell you, based on your weapon and your range system, where not to be caught.
        - Also, route planning - would tell you how visible you were on the

route and how visible the route was.

- The first pass of ISSP Statement of Requirements (SOR) would provide a quick list of the capabilities that are a priority. There are some constraints inherently in the list that gives higher priority to existing technology and cheaper solutions, but it would still serve as a good guide to find out which capabilities are higher priorities than others.

General: Commercial Hardware

- Apple iPhone has changed how users interact with handheld devices. One click pictures, auto geo referencing, their proprietary circle interface, etc are all highly useful capabilities. Hopefully ISSP will get at least that functionality in build three.
- In recent combat deployments, US troops had small operations areas. They all had palm pilots, and they took pictures of shops and families, and kept various pieces of information about the area in their Palm Pilots. Each troop was able to share this information with other members of their own troop, but not to other nearby troops. Ideally, this type of database is implemented system wide.
    - Who manages this data is a very important consideration
- The Micro-DAGR is a useful tool with a lot of functionality.

General: Google Maps

- Ideally, the soldiers should receive a tactical version of Google maps.
    - This means it has all of Google maps functionality but the map-based information is tailored to military teams.
    - The information should allow a soldier to query a shop, and find out the name of the owner, kids, date updated, etc. Then if that information is not the same as what is current, the soldier knows to start asking why the change. If the previous owner was a suspected Taliban member, then where did he go?
    - A similar level of information accessibility, with satellite images, with street view, etc. is all desired by soldiers. Both the map and satellite images give a different sense of reality. Both are useful.
- Mapping and charting in other places not covered by Google maps aims to provide the same information that Google maps does.
- Can use Google maps as the backbone, and then add on classified systems on top of it.
- What characteristics would be desired on top of Google maps?
    - Want engineering plans for buildings, layouts on the inside, heating, sewer, etc
    - Local trends, local census information. There is a problem as there is a current lack of this type of information.

Psychological Considerations: Finding and managing information

- Photos, routes, etc that were added some time (e.g., days, weeks, months) ago will need to be accessed and used. How is the information stored? Is it easily accessible? These are areas that have not been explored.
- Security is also an important consideration.
- Commanders talk about their desire to get information out to "the fringe" but what the definition of "the fringe" is differs from one Commander to another. Fringe could be Bn or Soldier level - not clear yet.
- In developed areas, information categories in GIS systems that exist in large urban centres can be selectable (e.g., power lines, sewers, hazardous materials, etc.)
    - It is not clear the extent to which that information can be used by soldiers, or who will need it.
    - Geo-mapping personnel want to create maps with all the same features listed above for the areas they go to.
- Might be useful to look at those GIS systems from other complex, risk oriented sociotechnical systems (e.g., EMS, fire responders, etc) to see what they use their GIS systems for, what information is on them, and what we can learn from them.
- Could implement a type of "Soldiers Wikipedia", or a wiki of theatre. This could contain information about what to look for, and all of it is geo-referenced (which Wikipedia does not currently do).
- Regression to familiar methods is a problem also – if soldiers don't find the new tools easy to use, they will just stick with radio or previous systems and stop using the device.

General: Texting

- The ability to text each other (using normal phrases, not codes, etc.) is also desired. This would be especially helpful for people with poor radio skills (currently they have to write down what they are going to say on the radio, so that they can then edit it properly). If they do not make sure the communication is accurate, then there is heavy criticism for wasting time on the radio.
- SIREQ looked at texting, also allowed personnel to send someone an indicator on a map, with a message (e.g., "See RV at 1725"). Message and location. This type of information exchange within a platoon (section 2ic, platoon cdr, etc) would be helpful.
- No one wants to have to sit at a keyboard while still having their hand on pistol
- Texting is a distraction also! This needs to be controlled in some respect. Could allow the use of familiar texting codes (i.e., UR = You're, etc) and other simple terms and shortcuts

Psychological Considerations: Head Up Issues

- The transition phase from heads up to heads down is a problem. Heads up displays do not fix the problem though. This has been found in other domains (e.g., airplanes), where the heads up displays became too engaging.

- This problem is not technology specific – also occurs when you give operators a map and compass where they do not look up. They have to learn to put their head up; it is part of the learning curve.

Psychological Considerations: Stress and Fatigue

- When people make decisions while fatigued there is a negative impact. Their mental state is not ideal; they have increased tunnel vision, calling grid references backwards, etc.
- While these effects are not particular to mobile GIS systems, simply giving operators more information compared to current systems will involve increased workload, etc. That should be considered in the design and whether or not the overall effect of having more information is positive.

Psychological Considerations: Level of information exchange

- An area that needs guidance is how to filter databases to determine who needs to see what, including dealing with crypto, etc. Higher command shouldn't be getting into the lowest levels of command, and lower levels do not need to see the highest level. How these levels of information requirements are filtered from each other has not been satisfactorily understood.
- There are issues when all levels have access to all information. Commanders can get caught up in minor details, and lower level commanders can get too involved in the bigger picture.
- This type of information filter would need to exist as one backbone system from high to low level

Psychological Considerations: Map based information sharing

- Information needs to be shared both vertically and horizontally. This means, both inside and outside your own "community of interest". There is a need to share or see info from other communities also.
- How your community is defined depends on where you are in the organization.
- The Army has done a fair bit of network analysis on this type of information sharing, including a map of network nodes, etc. This would be an important backbone for how information needs to be shared.
- Are there bottlenecks in the flow of information that have been identified - for example, that node X is key node (laterally and vertically)? This probably has been looked at, but no one in attendance knew of any specific examples. A larger problem is that the communication "pipes" the CF currently have to exchange information are too small. A lot of information is desired to be generated and pushed, but there currently is not the communication bandwidth to support it.
- Classification levels can become problematic also. As information is collated together, that then becomes classified.

General: Troop Changes

- "Shift changes" are a big deal. How the deployments currently work, there are 1000

soldiers in Afghanistan and then a 1 week overlap with the new 1000 troops that come in.

- They do write lessons learned that they hope future troops will learn from, but there is nothing yet in place to ensure that this information is being learned.
- Essentially, all the new troops have to relearn everything. It is difficult to pass on not only the quantity, but also the subtleties that would be required for a no gap transfer. But much of this information comes through months of experience.
- A common database would be useful to serve this purpose. Especially, if there could be a validation process for what is in the database. Some things may turn out to be incorrect – currently it is all just being forgotten.
- Also, the "bad guys" aren't stupid. It is at this time (i.e., change of troops) that they DO shift people around, because they know the new group isn't going to notice the new shop keeper, for example. When the enemy figures out the line between Unit A's area and Unit B's area – they know that is a gap, and they will exploit it.
- "The prisoners are not changing, the guards are."

Navigation: Route Planning: IEDs

- Hypothetically, if a solder were to suspect that a group of boulders on the side of the road was a problem – how would that get documented or communicated? Currently the individual would take a picture with a long lens and then determine location (or guess). This type of information, with the image, may or may not work its way up the system.
    - Perhaps in the future that point on the map could be marked and then annotated with text?
- The CF currently respond to potential IEDs quickly. They send someone to look at an IED. While the IED is being investigated it would be represented on the larger command map, but would not necessarily be on each soldier's map.
    - Other emergency calls (e.g., 9 liners) are also responded to very fast
    - Verbal reports with grid references are currently how this information is communicated
- The capability of recording IEDs visually may also assist in targeting, and can prepare any disarmament group as to what the potential type of IED it is.
- The concept of transitioning the police system for locating rapists into systems for locating IEDs would be very useful.

Psychological Considerations: Dynamic Changes in Focus

- This is the need to go from one picture to another picture and then back again quickly.
- The importance of the ability to do this depends on where you are in the chain of command. Your frequency of changing information screens should decrease if you are closer to the situation. Area of influence would also determine how much

zooming and panning is required.

- Platoon commanders would want to know where his soldiers are, flanking units, and down to soldier level for each of those three platoons. Then for other Co, section level icons are suitable. Could do some hot key (company icon) to see Co area of occupation.
- What about coming out of a battle? Would they then want to immediately switch to another view? When coming out of a battle, they have to do reports. So, they are really consolidating what is there now. Takes a while to start looking outside of where the commander is at now.
- In terms of information requirements: For planning, looking 2 down and 1 up. (The Land Warrior program had this reversed, as it was set up to look 2 up and one down, which was not effective).

Psychological Considerations: Uncertainty Representations

- Very Important.
- SIREQ used green, yellow, red to indicate recency of reporting (so older non-reporting systems would show red, telling the operators to essentially ignore it). Note: these particular colour codings conflict with standard NATO colours used to represent affiliation or threat status. Therefore, any specific coding method that is adopted in the future will need to avoid conflict and possible errors resulting from confusion with other symbology.

Psychological Considerations: Visualizations on Gaming Systems

- The gaming industry has done a fair bit of work on this (use of fading, etc). SOCOM and other "shoot-me-up" type games. Some are clever.
    - The CF should take advantage of the years of training gaming has provided.
    - Is it suitable enough for military use? If this type of prior experience means the need for training would be minimized, then transfer of experience from the gaming world to the military applications should be explored.

Psychological Considerations: Alarms and Alerts

- These can help individuals by alerting about how certain pre-defined states have changed, for example, alarms for mine fields.
- Could also use cues from other modalities (e.g., tactile cues for way finding). Or if personnel walk outside the path, alarm, etc.
- There is potential for a number of categories of alerts (navigation, low battery, communications problems, E-mail alerts, proximity alarms, jamming alerts, etc) which will all need a disciplined approach to them to prioritize and ensure clear display, rules for clearing alarms, etc.

Psychological Considerations: Symbology and Overlays

- Any system needs to give increased resolution as you zoom in, and then as an operator zooms out the information aggregates.

	• In general, clutter is a big problem. If operators were to use all overlays, they wouldn't see the map – just jumbled lines and colour. There currently exists little in terms of guidelines on how to deal with these types of icons and overlays, etc. • The typical workaround is to have user selectable overlays – that can be turned on and off manually. Additional training will be required to ensure that users understand the full range of overlays they have available. Psychological Considerations: After Action and Lessons learned • Post mortem analysis - could only be used as a training tool. But could conceive of a system that tracked what actions operators did, and where they went (e.g., could animate these actions on a screen). System could also know what information the operators had at that time. This could serve as essentially a replay of the events that occurred. o If this type of system existed, they would want the quality of the system to be admissible in court (like cell phone records currently are) o That is the level of rigor required. However, it is acknowledged that the first pass of this system would not necessarily be at that level – simply that it is a desired end state. • In Wainwright they have the 'West' system. Where you can replay a training exercise back.
7b	**Summary of Potential Research Areas** • What information is needed at what level (rifleman vs. commander). Who needs to know what and when. o There is primary vs. secondary vs. tertiary information. o The impact of personality on the information needs o Need to develop an understanding of how to implement filters for these systems at the crypto and database level • How to best display information when plans change o How to present the delta between your reality and others' mission plan. The earlier those deviations can be identified, the better, so that others can compensate. o For commanders. Predictive is better than reactive. The things that commanders are interested in predicting is very different at different command levels • Uncertainty - time late, etc. How is this visualized? There is a general tendency to assume if it is shown on the screen, then it is true. • There is a need to understand the tradeoffs between power requirements and information needs. For instance, if we have this much power available, then we should implement these 7 top priority information systems. If extra power becomes available, then we can add in the following 2 information systems, etc. Essentially

	prioritizing. • Can look at how other sophisticated GIS users are using their tools. And the level of information fidelity required. o SIREQ looked at 3D visualizations of QC City. Fly over, assemble 3D model, and start populating with intelligence. Found that the full 3D model was not what they required. Important information came from landmarks from different cross points in the city (e.g., if I'm here and I walk there, I then turn left at the Coca-Cola sign, etc) • Head up vs. head down issues. o In addition to what has been discussed already, processing power of the tool comes into play here also. Can get a soldier jamming up in the corner because the device is slow. Input/output options • The functionality of iPhone is what is desired but not necessarily the form factor. There is a need for the functionality on a weapons sight perhaps, and then a keyboard on the on weapon. Or a wrist watch. • Want the capabilities of a civilian cell phone - but not the box. Manufacturer tends to determine the box. • From studies done thus far, a touch screen works well - can get by doing texting, etc. SIREQ: Different roles require different inputs - agreed. Have looked at 6x10 wide tablets with plug-in. Have looked at gloves, cold, etc.
8	**Prioritization of issues (**Human*systems*®**)** A quick prioritization was requested of each attendee. HSI® led round table statements where each person stated their top 3. Results were as follows: Dave Tack: Alarms and Alerts; Uncertainty Representations; Symbology and overlays LCol Bodner: Symbology and Overlays; Gaming and other systems; Training Capt Dionne: Symbology and Overlays; Gaming and other systems; Training; Map based information sharing Capt Anderson: Map based information sharing; Alarms and Alerts Doug Palmer: Map based information sharing; Level of information exchange; Symboloy and overlays
9	**Wrap-up (**Human*systems*®**)** Everyone was thanked for their attendance. Contact information for HSI® was given out so attendees could provide any additional information. Meeting ended at 1530.

Annex 5 – Original Mind Map

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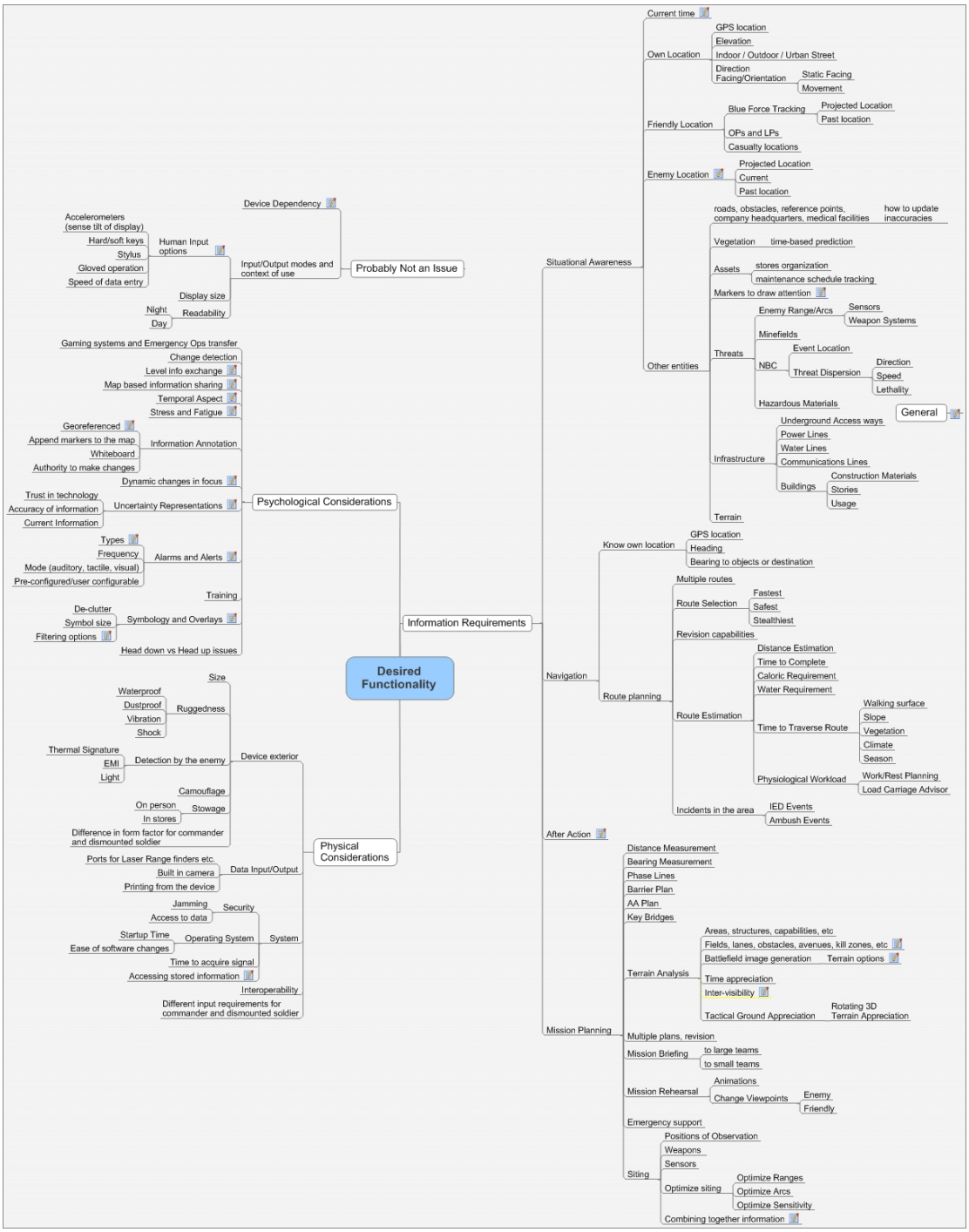
Annex 6 – Resulting Mind Map



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Acronym List

2D – Two-Dimension

3D – Three-Dimension

ASIC – All Source Intelligence Cell

Bn – Battalion

C2 – Command and Control

C4I – Command, Control, Communications, Computers and Intelligence

Capt – Captain

CF – Canadian Forces

CTA – Cognitive Task Analysis

CWA – Cognitive Work Analysis

DAGR – Defence Advanced GPS Receiver

DLR – Directorate of Land Requirements

DRDC – Defence Research and Development Canada

DSSPM – Director of Soldier Systems Program Management

DSTL – Director Science and Technology Land

EMS – Emergency Medical Service

GIS – Geospatial Information Systems

GPS – Global Positioning System

HQ – Headquarters

HTA – Hierarchical Task Analysis

IED – Improvised Explosive Device

ISSP – Integrated Soldier System Project

LCol – Lieutenant Colonel

MCpl – Master Corporal

NATO – North Atlantic Treaty Organization

QC – Quebec

SA – Situation Awareness

SIREQ – Soldiers Information Requirements

Sgt – Sergeant

SITREP – Situation Report

SOR – Statement of Requirements

SOCOM – Special Operations Command

US – United States